Limited Distribution



# Legumes Program

## Quarterly Technical Report

### January-March 1993

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
Patancheru, Andhra Pradesh 502 324, India

# Contents

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## Highlights

### Chickpea

- Yields of over 3 t $ha^{-1}$ were obtained in nonirrigated areas at ICRISAT Center.
- Ascochyta blight disease ratings of test genotypes at Hisar in the field disease nursery and in controlled environment disease screening at IC were found to agree closely (correlation coefficient of 0.9).
- In a collaborative study with the International Atomic Energy Agency (IAEA), Austria, and the National Agriculture Research Center (NARC), Japan, "A-value" and natural $^{15}N$ abundance methods were compared in quantification of nitrogen fixed by chickpea grown at Gwalior. By A-value assessment, 25-38% of the plants' nitrogen was derived from the atmosphere, which compared with 17-29% by natural abundance assessment.
- Presence of more than one luteovirus which can cause "stunt-like" symptoms in chickpea has been confirmed.
- Tissues from chickpea plants infected with chickpea stunt virus were cultured, and callus assayed for presence of virus. As virus was present in the callus, this holds promise as a source of virus independent of cropping seasons.
- A few $F_4$ and $F_5$ progenies from the interspecific hybridization program were resistant to cold at Tel Hadya (the principal ICARDA location), Breda (a dry location in Syria), and Terbol (a high altitude location in Lebanon). Interestingly some of them are already flowering, whereas none of the cultivars are flowering. It confirms our observation of last year that *Cicer echinospermum* and *Cicer reticulatum* can offer genes for both cold tolerance and early flowering.

### Pigeonpea

- In a short-duration indeterminate trial conducted at Modipuram, India, two newly developed lines ICPL 91039 and ICPL 91050 recorded 15 to 20% more yield than the control variety Manak.
- In a short-duration determinate trial conducted at Modipuram, ICPL 91013 outyielded the control ICPL 151 by a significant margin.
- In an extra-short-duration varietal trial conducted at Modipuram, ICPL 91011 and ICPL 92032 among determinate and ICPL 92047 among indeterminate lines outyielded the controls.
- In the Medium-duration Coordinated Hybrid Pigeonpea Trial sown at ICRISAT, hybrid AKPH 2080 produced significantly higher yield (2.34 t $ha^{-1}$) than the control BDN 2 (1.14 t $ha^{-1}$).
- A medium-duration wilt- and sterility mosaic-resistant line, ICPL 92060 produced significantly higher grain yield (2.07 t $ha^{-1}$) than the control variety C 11 (1.61 t $ha^{-1}$). This line will be included for testing in the Medium-duration Pigeonpea International Trial (MPIT) during the 1993/94 crop season.
- Four long-duration wilt- and sterility mosaic-resistant lines produced significantly higher grain yield (1.66 - 2.19 t $ha^{-1}$) than the best control NP(WR)15 (1.12 t $ha^{-1}$) at IC. These lines will be included in the Long-duration Pigeonpea International Trial (LPIT) for testing in the 1993/94 crop season.

- Observations on powdery mildew severity in the germplasm and breeding materials at IC, in Kenya, and in Malawi indicate that the African germplasm is resistant to powdery mildew.
- Observations on pigeonpea wilt incidence and seasonal rainfall data at IC during the 1989-92 rainy seasons indicated that the onset of wilt incidence coincides with decline of rainfall and increased moisture stress.
- The new insecticide resistance monitoring protocols developed at IC during the 1992/93 season proved to be highly successful for rapid monitoring of resistance problems in farmers' fields.
- Serious levels of pyrethroid, cyclodiene, and organophosphate resistance have been documented in *Helicoverpa armigera* populations in Andhra Pradesh.
- Bioassays on *Helicoverpa peltigera* from IC has shown that this species is fully susceptible to insecticides.
- Among the six short-duration pigeonpea genotypes evaluated for *Helicoverpa* ovipositional preference, ICPL 87 was preferred under both choice and nonchoice tests. Interestingly, ovipositional preference seemed to be related to flower color.
- Locally fabricated, manually operated rainout shelters were used to confirm earlier findings on the sensitivity of the flowering stage of extra-short-duration pigeonpea to grain yield reduction by drought stress. These shelters were also used to establish that this growth stage was also most sensitive to shading.
- Irrigation responses in the order of 20-30% were measured for grain yield of a range of medium-duration pigeonpea genotypes grown on a Vertisol in 1992/93. Further genotypic differences in response were noted.
- A root model was modified from one reported in the literature. The model simulates processes that determine root distribution in the soil, such as (i) increasing depth of the rooting front; (ii) the length/weight ratio of new roots; (iii) proliferation within soil layers; and (iv) senescence. The algorithms in the model performance provide sensitivity to soil, crop and environmental factors. The model is sufficiently flexible to allow simulation of root growth for a variety of soils, climates and species.

## Groundnut

- In the Fourth International Foliar Disease Resistance Groundnut Varietal Trial (IFDRGVT) conducted at the Central Agricultural Research Institute (CARI), Yezin, Myanmar, 10 varieties significantly outyielded the local control Simpadetha 2.
- In the elite trial the range of seed infection by *Aspergillus flavus* in 18 test varieties was from 0.3 to 3.7 ± 0.40%. Ten test varieties had up to 1.1% of their seeds infected by *A. flavus* compared to 1.3% in the resistant control J 11 and 11% in the susceptible control JL 24.
- Genomic DNA was isolated from putative transformants which were earlier found to be positive for the histochemical expression of the GUS gene. Blotted DNA was probed with the GUS fragment labelled with digoxigenin. All the putative transformants which were earlier found to be GUS positive histochemically showed hybridization with the probe.
- Of 19 insect pests-resistant groundnut varieties tested during the 1993 rainy season at the Agricultural Research Station, Darsi, Andhra Pradesh, ICGVs 86398, 86393, and 87445 recorded 44-91% greater pod yield than the local control TPT 2 (ICG 1706).
- Three foliar diseases-resistant selections ICGVs 87165, 86635, and 86977 showed promise for drought tolerance in Indonesia.
- The role of birds viz., egrets, drongoes, and some other unidentified passerines in suppression of *Helicoverpa* and *Spodoptera* in groundnut fields.
- Polythene mulch in groundnut fields suppressed thrips activity for up to 50 days after crop emergence.

- In a collaborative study with the Sukarami Research Institute for Food Crops (SARIF), Sitiung, Indonesia, on genotype x soil acidity x drought interactions in groundnut, the drought resistant genotypes ICGV 86635 and ICGV 86644 produced more aerial biomass than other genotypes under moderate soil acidity.
- Monoclonal antibodies for peanut mottle potyvirus, peanut green mosaic potyvirus, and peanut bud necrosis tospovirus have been produced and are highly specific.
- In collaboration with the scientists in the Virology Department of the Scottish Crop Research Institute (SCRI), UK, over 90% of the RNA 2 of Indian peanut clump furovirus (Hyderabad isolate) has been sequenced. Using this information clones which can detect all the currently known isolates from India have been identified.
- In joint surveys with the Indian Council of Agricultural Research (ICAR) scientists, peanut stripe virus was detected in experimental stations in Assam.

## Technology Exchange

- Adoption of ICRISAT's chickpea varieties by a farmer in a field adjacent to ICRISAT Center resulted in a yield of 1.5 t $ha^{-1}$.
- People's Republic of China has released two chickpea cultivars, namely "FLIP 81-40W" and "FLIP 81-71C", from the materials supplied by ICRISAT/ICARDA Chickpea Project. With these two releases, the number of cultivars released by the national programs have reached 50 in 17 countries.
- ICPL 151 and ICPL 83009 are being promoted by Siamati Ltd. of Thailand, a private enterprise for commercial cultivation. In 1993 about 200 ha are expected to be cultivated under these cultivars in Chiang Mai Province.
- Two derivatives of ICPL 295 have been identified for seed multiplication and distribution to farmers in the Philippines. The derivatives have been named "Brooks and Saludar".
- Farmers in two study villages were favorably impressed by several of our *Helicoverpa*-resistant pigeonpea genotypes, but farmers in one village thought that the crop duration of the 'best' genotype was too long.
- On-farm trials organized in coastal Andhra Pradesh to demonstrate the correct use of insecticides on groundnut created high awareness amongst farmers about the necessity of restricting insecticide applications to conserve natural enemies.
- The medium-duration virginia bunch variety, ICGV 86325, has done well in 4 years of testing since 1989 in the rainy season trials of the All India Coordinated Research Project on Oilseeds (AICORPO) in Zone V. The Project Coordinator has recommended its prerelease identification for consideration of the AICORPO Special Committee on Prerelease Identification of Groundnut Varieties.
- The performance of ICRISAT groundnut varieties in the front line demonstrations organized by the Zonal Coordination Unit for Transfer of Technology Projects (Zone V) for Andhra Pradesh, and Maharashtra (rainy and postrainy seasons) has been very encouraging. The general reaction of farmers in Maharashtra towards ICRISAT varieties has been very favorable. In Andhra Pradesh, the performance of ICGS 44 in Coastal sandy soils of Guntur and East Godavari Districts was excellent and farmers are enthusiastically adopting ICGS 44 in this area.
- The Hung Loc Agricultural Research Center of the Institute of Agricultural Sciences, Ho Chi Minh City, identified ICGS(E) 56 as one of the most suitable groundnut varieties for intercropping with cassava and maize in the southeast coastal and southeastern regions of Vietnam after evaluation in 33 field experiments and 6 trials involving 344 farming families. A bilingual (Vietnamese/English) pamphlet states:
  Two high-yielding groundnut varieties: Hung Loc 25 (HL 25), Hung Loc 28 (HL 28) and intensive cultivation technologies. The HL 25 (Pedigree: ICGS(E) 56) and the HL 28 (Pedigree: LOMPONG) are two high-yielding groundnut varieties, introduced from IFPRI under the Asian Farming Systems

Network Program in 1988. They were selected and recommended by Hung Loc Agricultural Research Center for cultivation.

The Center recommends two intercropping technologies.

Groundnut with cassava (1 cassava row and 2 groundnut rows).

Groundnut with maize (2 maize rows and 4 to 6 groundnut rows)

These cultivation technologies were found to be economical and to improve soil fertility.

- Zambian authorities have recently approved prerelease multiplication of ICGMS 5. The pedigree of ICGMS 5 is (Robut 33-1 x NC Ac 2698) F2-B2-P1-B1-B1-B1-B1-B1-B1-B1. This breeding line, developed at IC, was introduced into the SADC/ICRISAT Groundnut Project in 1982. It was included in the cooperative regional yield trials of the SADC region in the 1983/84 season as ICGMS 5. This is the second ICRISAT variety in line for release for cultivation in Zambia. The first ICRISAT variety, ICGMS 42, was released there as MGS 4 in 1990.
- ICGV 86564 [ICG(CG)S 49], a dual purpose groundnut breeding line, which was identified as an elite germplasm by the Plant Material Identification Committee of ICRISAT in 1992 is becoming increasingly popular with groundnut farmers in Maharashtra. This elite germplasm has an average oil content of 52% and a 100-seed mass of 90 g. In yield trials at ICRISAT Center during 1987/88 - 1989/90, ICGV 86564 produced, on average, 3 t pod $ha^{-1}$, 7% more than Chandra, a recommended confectionery variety in India. It has performed equally well in Burundi, Nepal, Pakistan, and Zambia where it showed 16-76% pod yield superiority over local cultivars. Because of its large seed mass, farmers in Maharashtra have renamed it as AP KAJU 49. We receive many seed requests with this new name.
- The Global Grain Legumes Drought Research Network (GGLDRN) was formally launched with the first issue of the Network newsletter "News and Views of GGLDRN".
- The First Cereals and Legumes Asia Network (CLAN) Review and Work Plan Meetings were held in Indonesia (18-19 Jan) and Thailand (21-22 Jan). The participants reviewed the past research on groundnut, sorghum, and pigeonpea, and prepared work plans containing details of collaborative research for their respective countries.
- A study tour of on-farm research trials in Nepal (8-12 Feb) and Vietnam (15-17 Feb) was organized by ICRISAT in collaboration with FAO-RAS/89/40 project. Representatives from 12 project countries and other organizations visited the on-farm research trials, and discussed with the scientists, extension staff, and farmers regarding planning and conduct of trials.
- A Regional Workshop on On-farm Adaptive Research, co-sponsored by FAO-RAS/89/40 project, CGPRT Centre, and ICRISAT was organized during 18-20 Feb 1993 in Ho Chi Minh City, Vietnam. Thirty-two participants from Bangladesh, China, Indonesia, South Korea, Laos, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam; FAO, CGPRT Centre, Asian Development Bank, and ICRISAT participated. The workshop participants appreciated the achievements of the Asian Grain Legumes On-farm Research (AGLOR) project in Indonesia, Nepal, Sri Lanka, and Vietnam and expressed desire to undertake similar activities in their countries.
- The second meeting of the Working Group on Botrytis Gray Mold (BGM) of chickpea was held during 14-17 Mar at Rampur, Nepal. Fifteen scientists from Bangladesh (2), India (3), Nepal (5), Pakistan (2), and ICRISAT (3) reviewed the research on BGM since the first meeting held in Dhaka in Mar 1991, and prepared plans for future research to manage BGM on chickpea.

# Research Activities

## Chickpea Breeding

**LC-002(90)IC/IC: Breeding desi chickpea for adaptation to different agroclimatic regions in the world — Extra-short- and short-duration chickpea**

**LC-003(90)IC/IC: Breeding desi chickpea for adaptation to different agroclimatic regions in the world — Medium-duration desi chickpea**

**LC-004(90)IC/IC: Breeding desi chickpea for adaptation to different agroclimatic regions in the world — Long-duration desi chickpea**

**Scientists: OS, JK, SCS, HAvR**

The prolonged cool period of January and February at ICRISAT Center (IC) was favorable for growth, pod formation, and seed-set of chickpea. The information received from Gwalior, Hisar, and Pantnagar on cooperative trials was positive and we expect useful results from the current season. However, some patches of salinity were noted in the fields at Hisar, while the kabuli trials had poor germination at Gwalior. As reported in the Quarterly Technical Report of Oct-Dec 1992, pod borer damage was severe in the non-sprayed fields at IC, especially in BUS 9B. Test genotypes differed greatly in their ability to recover from the pest damage; the resistant ones showed good regrowth but and the susceptible control had poor recovery. Pod and seed damage counts were taken and are being analyzed.

At IC data were obtained on wilt and root rot resistance of trial entries, and screening of early segregating cross populations was completed. This will result in establishment of resistant bulks or resistant single plant progenies. Data from some trials in nonirrigated fields have been analyzed with the results shown in **Table 1**. Growing conditions were very favorable as evidenced by a maximum yield of 3.33 t $ha^{-1}$ based on average plot yields. It is interesting to compare these yields on our experiments with the mean yield of 1.36 t $ha^{-1}$ of a chickpea varieties grown by a local farmer on a field adjacent to ICRISAT research farm (**Table 2, Fig. 1**).

**LC-006(90)IC/IC: Breeding kabuli chickpea for adaptation to different agroclimatic regions in the world — Extra-short- and short-duration kabuli chickpea**

**LC-007(90)IC/IC: Breeding kabuli chickpea for adaptation to different agroclimatic regions in the world — Medium-duration kabuli chickpea**

**LC-008(90)IC/IC: Breeding kabuli chickpea for adaptation to different agroclimatic regions in the world — Long-duration kabuli chickpea**

**Scientists: JK, SCS, HAvR, OS**

The activities under the kabuli chickpea projects were similar to those described for Project LC-002-004. At Gwalior seedling emergence was very poor, and no meaningful data were obtained. At IC seedling emergence in both irrigated and non-irrigated fields was satisfactory, except in Field BIL 2D where the plant stand was variable. In the nonsprayed fields, a number of kabuli trial entries, specially ICCV 6 mutants, were severely damaged by *Helicoverpa armigera* and pod borer failed to recover, but other entries recovered and yielded well.

**Table 1. Performance of chickpea entries in the ICSN-DS (PA 26892R) at ICRISAT Center, 1992/93.**

| Entry | Days to 50% flowering | Days to maturity | 100-seed mass (g) | Seed yield kg/ha | Seed yield Rank |
|---|---|---|---|---|---|
| ICC 4918(c) | 55 | 110 | 19.3 | 3052 | 7 |
| ICCV 90003 | 56 | 107 | 19.6 | 3076 | 5 |
| ICCV 90006 | 56 | 111 | 20.2 | 3081 | 4 |
| ICCV 90009 | 59 | 112 | 17.8 | 3146 | 2 |
| ICCV 90011 | 59 | 116 | 21.7 | 2398 | 37 |
| ICCV 90025 | 58 | 110 | 17.3 | 2926 | 14 |
| ICCV 90027 | 58 | 114 | 27.8 | 2841 | 20 |
| ICCV 90034 | 56 | 108 | 18.9 | 2650 | 33 |
| ICCV 90035 | 54 | 106 | 28.8 | 2810 | 23 |
| ICCV 90037 | 58 | 108 | 26.2 | 2957 | 12 |
| ICCV 92001 | 58 | 113 | 20.2 | 3026 | 8 |
| ICCV 92002 | 59 | 110 | 26.2 | 3326 | 1 |
| ICCV 92003 | 62 | 115 | 17.6 | 2836 | 21 |
| ICCV 92004 | 58 | 107 | 25.4 | 2491 | 35 |
| ICCV 92005 | 59 | 111 | 25.0 | 2681 | 31 |
| ICCV 92006 | 58 | 107 | 23.5 | 2845 | 19 |
| ICCV 92007 | 60 | 111 | 25.6 | 2366 | 38 |
| ICCV 92008 | 59 | 111 | 22.4 | 2914 | 15 |
| ICCV 92009 | 60 | 113 | 17.1 | 3026 | 8 |
| ICCV 92010 | 58 | 108 | 24.5 | 2850 | 18 |
| ICCV 92011 | 63 | 114 | 23.9 | 3019 | 9 |
| ICCV 92012 | 57 | 108 | 19.4 | 2717 | 27 |
| ICCV 92013 | 56 | 108 | 26.6 | 2793 | 24 |
| ICCV 92014 | 60 | 110 | 25.1 | 2905 | 16 |
| ICCV 92015 | 57 | 109 | 17.4 | 2779 | 25 |
| ICCV 92016 | 57 | 107 | 16.2 | 3053 | 6 |
| ICCV 92017 | 58 | 107 | 20.9 | 2655 | 32 |
| ICCV 92018 | 55 | 106 | 21.0 | 2514 | 34 |
| ICCV 92019 | 60 | 112 | 19.8 | 2819 | 22 |
| ICCV 92020 | 60 | 115 | 18.6 | 2736 | 26 |
| ICCV 92021 | 59 | 112 | 18.4 | 2681 | 31 |
| ICCV 92022 | 59 | 111 | 23.5 | 2691 | 28 |
| ICCV 92023 | 61 | 114 | 19.3 | 2860 | 17 |
| ICCV 92024 | 58 | 114 | 18.4 | 2686 | 29 |
| ICCV 92025 | 55 | 107 | 32.1 | 2933 | 13 |
| ICCV 92026 | 56 | 112 | 27.9 | 2405 | 36 |
| ICCV 92027 | 58 | 113 | 20.6 | 2686 | 30 |
| ICCV 92028 | 58 | 112 | 20.7 | 3138 | 3 |
| ICCV 92029 | 58 | 111 | 18.9 | 2962 | 11 |
| ICCC 37 | 58 | 111 | 24.8 | 3000 | 10 |
| SE | ±1.2 | ±1.6 | ±1.02 | ±160.6 | |
| Mean | 57.8 | 110.3 | 21.94 | 2833.1 | |
| CV (%) | 3.0 | 2.0 | 6.55 | 8.0 | |

**Table 2. Yields of on-farm chickpea grown without irrigation adjacent to ICRISAT Campus, Patancheru, postrainy season 1992/93.**

| Variety | Yield[1] (t $ha^{-1}$) |
|---|---|
| ICCC 37 | 1.24 |
| ICCCV 2 | 1.15 |
| ICCV 10 | 1.50 |
| ICCV 88202 | 1.49 |
| Annigeri | 1.41 |
| Mean | 1.36 |
| SE | ±0.128 |
| CV(%) | 18.8 |

1. Plot size = 25 $m^2$.

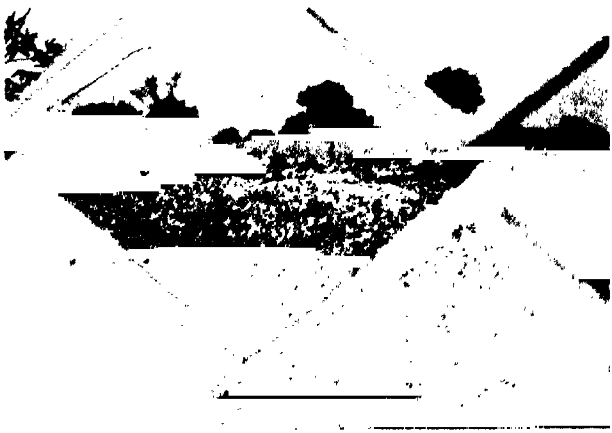

*Figure 1. View of local farmers chickpea crop taken from within ICRISAT Center Farm, postrainy season 1992/93.*

The cultivar ICCV 2, released under the name Swetha, impressed farmers by its short duration and comparatively large seed size, but for a kabuli type, the seed size can be further improved. A number of short duration, wilt and root rot resistant, large-seeded (>40 g 100 seeds$^{-1}$), high yielding varieties are ready for further testing in international nurseries. Some of these have already performed well in Maharashtra State, India. Several single plant selections in $F_4$ populations, from crosses involving a tall, Russian introduction; they combined good growth habit with large seed size.

**LC-010(90)IC/IC: Breeding desi and kabuli chickpeas for specific situations in the world — Adaptation to early sowing (including sowing during the rains)**

**LC-011(90)IC/IC: Breeding desi and kabuli chickpeas for specific situations in the world — Adaptation to late sowing**

**LC-012(90)IC/IC: Breeding desi and kabuli chickpeas for specific situations in the world — Adaptation to high fertility and irrigation**

**LC-013(90)IC/IC: Breeding desi and kabuli chickpeas for specific situations in the world — Adaptation to rice-based cropping systems**

**Scientists: SCS, OS, JK, HAvR.**

The July-sown experiments, that had suffered from rain, drought, and severe *H. armigera* attack produced very low yields. Some of the entries were later sown at the normal time and have shown better growth and less *H. armigera* damage, and higher yields are expected.

The experiments conducted under project LC-012 (Adaptation to high fertility and irrigation) were sown only at Gwalior and Hisar.

**LC-015(90)IC/IC: Germplasm enhancement for biotic stresses — Resistance to ascochyta blight**

**LC-016(90)IC/IC: Germplasm enhancement for biotic stresses — Resistance to *Helicoverpa* pod borer**

**Scientists: JK, OS, MPH, TGS.**

The ascochyta blight resistance screening continued in the "chickpea growthroom". To illustrate the relevance of screening under growthroom conditions, we present disease scores from the growth room and from field screening along with their correlations (**Table 3**). The coefficient of correlation was 0.9, showing that the facility enables satisfactory testing for ascochyta blight resistance.

The $F_2$ populations of double crosses, and $F_3$ and $F_4$ progenies, derived from promising single plants, selected for *Helicoverpa* resistance, were further screened under nonsprayed conditions by counting and recording the numbers of damaged and undamaged pods. The early-season damage was severe, and clear differences between plants were noted, but late-season damage was less severe and differences between plants were much less than expected.

**Table 3. Mean ascochyta blight disease scores for 21 chickpea varieties tested in field conditions at Hisar, and in growthroom conditions at ICRISAT Center after inoculation with the Hisar isolate of *Ascochyta rabiei*.**

| | Disease Scores[1,2] | | | Disease Scores[1,2] | |
|---|---|---|---|---|---|
| Variety/cross | Hisar | Growth-room | Variety/cross | Hisar | Growth-room |
| ICC 607 | 9.0 | 9.0 | ICC 1065 | 9.0 | 9.0 |
| ICC 1400 | 5.0 | 6.0 | ICC 1472 | 9.0 | 9.0 |
| ICC 12967 | 9.0 | 9.0 | ICC 13416 | 9.0 | 9.0 |
| ICC 13816 | 5.5 | 5.5 | ICC 14911 | 6.0 | 7.0 |
| ICCL 86446 | 5.5 | 6.0 | ICCL 86447 | 5.0 | 5.0 |
| ICCV 89445 | 5.0 | 7.0 | ICCX 790151 | 4.5 | 5.0 |
| ICCX 800839 | 7.0 | 7.0 | ICCX 800859 | 4.0 | 5.0 |
| ICCX 810457 | 6.0 | 7.0 | ICCX 810737 | 7.0 | 9.0 |
| ICCX 810737 | 5.5 | 7.0 | ICCX 810800 | 4.5 | 6.0 |
| ICCX 810974 | 4.0 | 6.0 | ICCX 830677 | 5.5 | 5.0 |
| Pb 7 | 9.0 | 9.0 | | | |

1. Disease score : 1 = no symptoms, 9 = killed by disease.
2. R = 0.9067; $R^2$ = 0.822; variation explained by linear regression = 82%

**CC-017(90)IC/IC: Upstream and backstop research**

**Scientists: HAvR, OS, SCS/JK**

Ideotype breeding continued by backcrossing selected $F_2$ plants to the recurrent parents. Seed from $F_1$ plants and backcrosses were obtained for studies on resistance to dry root rot, and on seed size and protein content.

A root study conducted by the Crop Physiology, Genetic Resources, and Chickpea Breeding Units using the parents ICC 4958 and Annigeri and their $F_1$, $F_2$ and backcrosses, yielded the following preliminary results:

| Contributing effects | Percentage of contribution |
|---|---|
| Additive [d] | 74 |
| Dominance [h] | 6 |
| Additive x additive [i] | 13 |
| additive x dominance [j] | 6 |
| Dominance x dominance [1] | 1 |

The observations on $F_2$ plants of the interspecific cross *Cicer arietinum* and *C. echinospermum* continued. Isozyme analyses were completed. Harvesting had started, but many plants were still green at the end of March.

## Pigeonpea Breeding

**LP-301(90)IC/IC: Development of short-duration pigeonpea cultivars for high yield, dwarfness, stability, wide adaptation and acceptability**

**Scientists: NBS, RPA**

Yield data of trials harvested during the last part of the rainy season at IC and at Modipuram were analyzed. Final selection of lines derived from different crosses/generations were made. The results of some trials are summarized below.

**(i) Performance of extra-short-duration determinate and indeterminate lines at Modipuram**

Twenty-eight newly developed extra-short-duration lines were evaluated at Modipuram during the 1992 rainy season. Determinate extra-short-duration lines flowered in about 72 days and matured in about 117 days at this location. Promising determinate lines which yielded more than the control (ICPL 4) were ICPLs 91011, 92032, 90002, 92029, 91002, and 92030 (**Table 4**).

Indeterminate extra-short-duration lines flowered in about 79 days and matured in about 127 days. The promising indeterminate lines were ICPLs 92047, 91024, 92044, and 91031 (**Table 5**). The performance of these lines at IC was described in last quarter's report.

**Table 4. Performance of some newly-developed extra-short-duration pigeonpea lines grown at Modipuram, India, rainy season 1992.**

| ICPL No. | Days to 50% flowering | Days to maturity | Plant height (cm) | 100-seed mass (g) | Grain yield (t ha$^{-1}$) |
|---|---|---|---|---|---|
| 91011 | 73 | 119 | 120 | 8.2 | 1.55 |
| 92032 | 69 | 112 | 110 | 9.1 | 1.37 |
| 90002 | 72 | 114 | 109 | 8.2 | 1.27 |
| 92029 | 69 | 115 | 117 | 9.3 | 1.26 |
| 91002 | 69 | 114 | 103 | 9.9 | 1.23 |
| 92030 | 66 | 109 | 106 | 8.7 | 1.21 |
| Control | | | | | |
| ICPL 4 | 81 | 122 | 111 | 5.4 | 0.72 |
| SE | ± 1.74 | ±2.33 | ± 6.62 | ± 0.30 | ± 0.16 |
| Mean (n=14) | 72.0 | 116.6 | 109.9 | 9.1 | 1.1 |
| CV (%) | 4.1 | 3.5 | 10.4 | 5.8 | 25.5 |

**Table 5. Performance of some newly-developed extra-short-duration indeterminate (NDT) pigeonpea lines grown at Modipuram, India, rainy season 1992.**

| ICPL No. | Days to flowering | Days to maturity | Plant height (cm) | 100-seed mass (g) | Grain yield ($t\ ha^{-1}$) |
|---|---|---|---|---|---|
| 92047 | 83 | 134 | 172 | 7.8 | 1.63 |
| 91024 | 82 | 126 | 177 | 7.5 | 1.55 |
| 92044 | 82 | 130 | 192 | 8.8 | 1.41 |
| 91031 | 80 | 132 | 190 | 9.4 | 1.41 |
| Control | | | | | |
| UPAS 120 | 83 | 132 | 167 | 7.3 | 1.29 |
| SE | ± 1.96 | ± 1.75 | ± 9.06 | ± 0.27 | ± 0.157 |
| Mean (n=14) | 79.4 | 126.6 | 168.0 | 8.00 | 1.25 |
| CV (%) | 4.2 | 2.3 | 9.3 | 5.9 | 21.8 |

**(ii) Performance of short-duration determinate and indeterminate lines at Modipuram**

Eighteen newly-developed determinate short-duration lines were evaluated at Modipuram during the 1992 rainy season. Average duration of these lines was 121 days and plant height about 120 cm. Promising lines among these were ICPLs 91013, 89029, 92038, and 92040 (**Table 6**). The best entry ICPL 91031 (2.0 $t\ ha^{-1}$) significantly outyielded the control ICPL 151 (1.5 $t\ ha^{-1}$).

Twenty indeterminate short-duration lines were evaluated at Modipuram during the 1992 rainy season. These lines matured in about 135 days but were tall (186 cm); those showing acceptable performance were ICPLs 91039, 91050, and 91049 (**Table 7**).

**(iii) Performance of extra-short-duration lines in Andhra Pradesh (ICRISAT-APAU trials)**

A set of ten extra-short-duration lines along with a hybrid were evaluated at 14 locations in Andhra Pradesh during the rainy season of 1992 for the third successive year under the ICRISAT-APAU collaborative program. The results from nine locations were received and analyzed. Among the extra-short-duration entries tested, ICPL 84031 (**Table 8**) recorded the highest average yield (1.05 $t\ ha^{-1}$). The grain yield of this line ranged from 0.47 to 1.78 $t\ ha^{-1}$ at different locations. Two other lines which recorded an average yield of about 1 $t\ ha^{-1}$ were ICPL 84052 and ICPL 88034. The hybrid ICPH 8 recorded an average of 1.22 $t\ ha^{-1}$. However, it matured 10 to 15 days later than the extra-short-duration lines.

**Reaction of newly developed pigeonpea lines to sterility mosaic and wilt diseases**

New lines were evaluated in a sterility mosaic and wilt sick nursery during the rainy season 1992. Among the lines tested ICPLs 92044, 92050, 92051, 92030, 92028, and 92040 showed less than 20% incidence of sterility mosaic. The lines ICPL 92044 and ICPL 90013 showed combined resistance to sterility mosaic and wilt (**Table 9**).

**Table 6. Performance of some newly-developed short-duration DT pigeonpea lines grown at Modipuram, India, rainy season 1992.**

| ICPL No. | Days to flowering | Days to maturity | Plant height (cm) | 100-seed mass (g) | Grain yield ($t\ ha^{-1}$) |
|---|---|---|---|---|---|
| 91013 | 72 | 118 | 120 | 10.5 | 1.97 |
| 89029 | 72 | 120 | 126 | 8.9 | 1.68 |
| 92038 | 67 | 113 | 129 | 10.4 | 1.67 |
| 92040 | 68 | 114 | 112 | 9.1 | 1.63 |
| Control | | | | | |
| ICPL 151 | 75 | 119 | 119 | 11.5 | 1.49 |
| SE | ± 2.74 | ± 2.83 | ± 4.04 | ± 0.30 | ± 0.194 |
| Mean (n=18) | 75.1 | 121.0 | 120.2 | 10.5 | 1.47 |
| CV (%) | 6.3 | 4.0 | 5.8 | 5.0 | 22.8 |

**Table 7. Performance of some newly-developed short-duration NDT pigeonpea lines grown at Modipuram, India, rainy season 1992.**

| ICPL No. | Days to flowering | Days to maturity | Plant height (cm) | 100-seed mass (g) | Grain yield ($t\ ha^{-1}$) |
|---|---|---|---|---|---|
| 91039 | 86 | 134 | 209 | 8.2 | 2.13 |
| 91050 | 84 | 130 | 189 | 8.2 | 2.05 |
| 91049 | 90 | 137 | 187 | 8.5 | 1.88 |
| Control | | | | | |
| Manak | 85 | 133 | 164 | 6.4 | 1.80 |
| SE | ± 1.53 | ± 2.16 | ± 7.91 | ± 0.21 | ± 0.186 |
| Mean (n=20) | 88.4 | 135.4 | 186.5 | 8.3 | 1.67 |
| CV (%) | 3.0 | 2.7 | 7.3 | 4.38 | 19.3 |

**Table 8. Performance of extra-short-duration pigeonpea lines grown at nine locations under the APAU-ICRISAT Collaborative Varietal Trial in Andhra Pradesh, India, rainy season 1992.**

| | | Yield (kg ha⁻¹) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ICPL No | Growth habit | Jagtial | Lam | Ragol | Yella-manchili | Madhira | Warangal | Patan-cheru | Tirupati | Darsi | Mean |
| 84031 | DT | 1736(3)[1] | 1276(4) | 699(5) | 4693) | 791(1) | 889(1) | 1781(9) | 569(6) | 1242(1) | 1050 |
| 85010 | DT | 1446(5) | 995(8) | 652(6) | 139(9) | 630(3) | 485(8) | 1167(11) | 578(5) | 578(11) | 741 |
| 86005 | DT | 632(11) | 860(11) | 593(7) | 374(5) | 254(12) | 621(4) | 2639(2) | 476(10) | 883(10) | 792 |
| 87105 | DT | 829(10) | 910(9) | 370(11) | 372(6) | 342(11) | 551(6) | 2071(7) | 611(3) | 783(8) | 760 |
| 88001 | DT | 2237(1) | 1045(7) | 457(9) | 393(4) | 621(4) | 465(9) | 1264(10) | 474(11) | 926(7) | 876 |
| 88026 | DT | 1296(6) | 903(10) | 1002(1) | 550(1) | 437(9) | 346(12) | 1968(8) | 481(8.5) | 1195(2) | 909 |
| ICPH 8 | NDT | 1928(2) | 1262(5) | 938(2) | 543(2) | 562(7) | 708(3) | 3219(1) | 791(1) | 1091(4) | 1227 |
| 84052 | NDT | 945(9) | 1581(1) | 716(3) | 133(11) | 696(2) | 613(5) | 2200(5) | 685(2) | 1099(3) | 983 |
| 88034 | NDT | 1450(11) | 1397(3) | 709(4) | 204(7) | 583(6) | 745(2) | 2384(3) | 481(8.5) | 1022(6) | 997 |
| 88039 | NDT | 1099(8) | 1134(6) | 382(10) | 135(10) | 554(8) | 391(11) | 1057(12) | 520(7) | 740(9) | 688 |
| 89016 | NDT | 1215(7) | 1508(2) | 585(8) | 93(12) | 600(5) | 518(7) | 2111(6) | 580(4) | 987(8) | 911 |
| Control | | - | 794(12) | - | 154(8) | 408(10) | 411(10) | 2251(4) | - | - | - |
| SE | | ± 170.2 | ± 99.3 | ± 19.4 | ± 10.0 | ± 20.6 | ± 83.5 | ± 152.4 | ± 27.0 | ± 179.0 | |
| Mean | | 1346.7 | 1138.8 | 645.8 | 296.5 | 539.8 | 562.0 | 2009.4 | 567.8 | 940.5 | |
| CV (%) | | 21.9 | 15.1 | 5.2 | 5.8 | 6.6 | 25.7 | 13.1 | 8.2 | 33.0 | |

1. Figures in parentheses indicate ranking of entries

**Table 9. Reaction of newly-developed ICPL lines to sterility mosaic and wilt diseases in a sick plot, ICRISAT Center, rainy season 1992.**

| | Percent incidence of | |
|---|---|---|
| ICPL No. | Wilt | Sterility mosaic |
| 92040 | 61.9 | 17.5 |
| 92044 | 10.0 | 14.3 |
| 92050 | 64.7 | 15.4 |
| 92051 | 27.7 | 9.3 |
| 92052 | 20.2 | 20.2 |
| 92028 | 54.2 | 16.5 |
| 92030 | 43.8 | 9.5 |
| 90013 | 14.0 | 14.3 |
| 91002 | 85.0 | 7.3 |
| 91017 | 85.7 | 8.5 |

**LP-302(90)IC/IC: Development of medium- and long-duration pigeonpea for high yield and stability**

**Scientists: KCJ, RPA**

**Medium duration**. We completed crosses for the development of materials for resistance to phytophthora blight, sterility mosaic and *Helicoverpa* pod borer. All the yield trials and breeding materials and promising selections from disease nurseries have been harvested and data from yield trials statistically analyzed.

**Performance of wilt and sterility mosaic resistant lines**. Nineteen wilt and sterility mosaic resistant lines and the standard control cultivar C 11 were tested for yield under rainfed conditions and for their reaction to wilt and sterility mosaic in the disease screening nursery. ICPL 92060 was the highest-yielding line producing 2.07 t $ha^{-1}$ compared to 1.61 t $ha^{-1}$ for the best control C 11. Seven other lines having similar yield as C 11 and ICPL 87119 controls showed combined resistance to wilt and sterility mosaic (**Table 10**). The wilt and sterility mosaic incidence in these progenies ranged from 1 to 10%. We plan to include them in the Medium-duration Pigeonpea International Trial during the 1993/94 season.

**Performance of wilt resistant lines**. The yield performance and wilt resistance of 18 lines were tested under rainfed conditions at IC during the 1992/93 crop season. One line (ICPX 870111-W10-WB-WB) was significantly higher yielding (2.06 t $ha^{-1}$) than the control C 11 (1.61 t $ha^{-1}$). Two cream-seeded mutant lines developed from ICP 8863 had yields similar to that of the control ICP 8863 (**Table 11**). These lines will be useful in areas where wilt is serious and a cream seed color is preferred over the normal type. The percentage incidence of wilt in these lines ranged between 4 and 11% compared to 26% in the control C 11.

**Table 10. Performance of medium-duration wilt and sterility mosaic (SM) resistant lines at ICRISAT Center, crop season 1992/93.**

| Entry No. | Entry Name | Grain yield (t $ha^{-1}$) | Days to Flower | Days to Mature | Plant height (cm) | 100-seed mass (g) | Seeds per pod | Plant stand | Percent incidence Wilt | Percent incidence SM |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | ICPL 92060 | 2.07 | 111 | 157 | 194 | 9.9 | 3.8 | 41 | 4 | 6 |
| 2 | ICPL 92057 | 1.82 | 110 | 157 | 186 | 9.3 | 3.5 | 42 | 5 | 7 |
| 14 | ICPL 92069 | 1.82 | 113 | 158 | 187 | 9.9 | 3.5 | 41 | 1 | 3 |
| 4 | ICPL 92059 | 1.81 | 105 | 153 | 176 | 9.6 | 3.9 | 39 | 10 | 9 |
| 7 | ICPL 92062 | 1.74 | 110 | 156 | 186 | 9.6 | 3.7 | 41 | 7 | 5 |
| 11 | ICPL 92066 | 1.71 | 110 | 156 | 182 | 10.1 | 3.6 | 42 | 2 | 2 |
| 10 | ICPL 92065 | 1.69 | 110 | 157 | 186 | 9.6 | 3.6 | 39 | 3 | 1 |
| 15 | ICPL 92070 | 1.62 | 110 | 156 | 179 | 9.7 | 3.3 | 38 | 1 | 2 |
| Controls | | | | | | | | | | |
| 19 | C 11 | 1.61 | 112 | 158 | 171 | 10.2 | 3.7 | 35 | 21 | 95 |
| 20 | ICPL 87119 | 1.60 | 113 | 157 | 176 | 10.3 | 3.5 | 36 | 3 | 4 |
| | SE | ±0.109 | ±0.5 | ±0.4 | ±3.8 | ±0.19 | ±0.15 | ±2.1 | | |
| | Mean (n=20) | 1.61 | 111 | 157 | 183 | 9.6 | 3.6 | 38 | | |
| | CV (%) | 12 | 1 | 1 | 4 | 3 | 7 | 10 | | |

**Table 11. Performance of medium-duration wilt-resistant lines at ICRISAT Center, crop season 1992/93.**

| Entry No | Name | Grain yield (t ha⁻¹) | Days to Flower | Days to Mature | Plant height (cm) | 100 seed mass (g) | Seeds per pod | Plant stand | Percentage incidence of wilt |
|---|---|---|---|---|---|---|---|---|---|
| 14 | ICPX 870111-W10-WB WB-B | 2.06 | 112 | 156 | 169 | 8.5 | 3.8 | 42 | 11 |
| 1 | ICP 8863-5kR-1-WB-WB-B | 1.88 | 107 | 154 | 167 | 9.0 | 4.0 | 43 | 7 |
| 2 | ICP 8863-5kR-2-WB-WB-B | 1.85 | 110 | 154 | 167 | 9.6 | 3.9 | 35 | 4 |
| 13 | ICPX 870108-WB WB-WB-B | 1.83 | 107 | 153 | 178 | 9.0 | 3.8 | 44 | 9 |
| 15 | ICPX 87011-W11-WB-WB-B | 1.76 | 114 | 157 | 178 | 8.9 | 3.9 | 41 | 6 |
| 16 | ICPX 860109-WE60-WH4-WHB-WB-B | 1.74 | 109 | 153 | 169 | 9.8 | 4.3 | 32 | 8 |
| Controls | | | | | | | | | |
| 20 | ICP 8863 | 1.74 | 106 | 154 | 174 | 9.4 | 3.8 | 39 | 9 |
| 19 | C 11 | 1.61 | 114 | 161 | 173 | 9.7 | 3.7 | 36 | 26 |
| | SE | ±0.131 | ±0.7 | ±0.8 | ±2.9 | ±0.15 | ±0.15 | ±2.9 | |
| | Mean (n=20) | 1.57 | 113 | 164 | 177 | 9.2 | 3.9 | 39 | |
| | CV (%) | 14 | 1 | 1 | 3 | 3 | 7 | 13 | |

**Long duration.** The long-duration trials and breeding materials have been harvested, and data from yield trials have been statistically analyzed. Due to high wilt incidence in many entries in the Long-duration Pigeonpea International Trial (LPIT), Sterility Mosaic Resistant Advanced Lines Trial (SMALT), and Short-statured Progenies Trial (SPT) yield data and other ancillary observations have not been recorded.

**Performance of wilt and sterility mosaic resistant lines**. Fifteen wilt and sterility mosaic resistant lines and the two control cultivars NP(WR)15 and T 7 were tested for yield and wilt and sterility mosaic resistance at IC during the 1992/93 crop season. Four lines were significantly higher yielding than the highest-yielding control NP(WR)15 (**Table 12**). The wilt and sterility mosaic incidence in these lines ranged from 4 to 13% and 1 to 10% respectively, compared to 21% wilt and 16% sterility mosaic incidence in the best control cultivar NP(WR)15. We plan to test their performance in the Long-duration Pigeonpea International Trial in the 1993/94 crop season.

**LP-303(90)IC/IC: Development of hybrids and their seed production technology**

**Scientists: KBS, RPA**

**Performance of experimental hybrids in AICPIP coordinated trials.** Three coordinated hybrid pigeonpea trials were supplied by AICPIP for testing at IC. Each test entry was evaluated in two-row plots, replicated twice. In the short-duration determinate and short-duration indeterminate trials a wide range was observed for days to flowering, duration, and plant type. The coefficients of variation in these trials was high (>40%). The hybrids GPH 344 (2.53 t $ha^{-1}$) in the determinate group and PPH 3 (2.89 t $ha^{-1}$) in the indeterminate group were the highest yielders.

In the Medium-duration Coordinated Hybrid Pigeonpea Trial, 20 hybrids were evaluated along with C 11 and BDN 1 as controls. AKPH 2080, a hybrid from Akola, produced significantly higher yield (2.34 t $ha^{-1}$) than the control variety BDN 2 (1.14 t $ha^{-1}$). This hybrid has seed of similar size to that of the control (**Table 13**).

**Table 12. Performance of long-duration wilt and sterility mosaic (SM) resistant lines, ICRISAT Center, crop season 1992/93.**

| Entry No. | Entry Name | Grain yield (t ha⁻¹) | Days to Flower | Days to Mature | Plant height (cm) | 100-seed mass (g) | Seeds per pod | Plant stand | Percentage incidence wilt | Percentage incidence SM |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | ICPL 87131-G32-GB-SWB-B | 2.19 | 146 | 210 | 238 | 9.4 | 3.4 | 23 | 7 | 10 |
| 15 | ICP 9174-273-GB-GB-GB-B | 1.85 | 146 | 210 | 213 | 9.8 | 3.9 | 23 | 4 | 5 |
| 3 | ICPX 85370-B-G39-GB-SWB-B | 1.67 | 146 | 210 | 230 | 9.0 | 3.5 | 23 | 13 | 6 |
| 1 | ICPX 85363-G1-GB-G60-G3-GB-SWB-B | 1.66 | 145 | 209 | 232 | 8.9 | 3.8 | 21 | 11 | 1 |
| Controls | | | | | | | | | | |
| 17 | NP(WR) 15 | 1.12 | 148 | 212 | 218 | 8.2 | 3.3 | 22 | 21 | 16 |
| 18 | T 7 | 0.85 | 148 | 212 | 223 | 10.2 | 3.5 | 13 | 13 | 27 |
| | SE | ±0.192 | ±1.0 | ±1.1 | ±7.1 | ±0.20 | ±0.16 | ±1.5 | | |
| | Mean (n=17) | 1.41 | 148 | 211 | 228 | 9.4 | 3.6 | 20 | | |
| | CV (%) | 24 | 1 | 1 | 5 | 4 | 8 | 13 | | |

**Table 13. Performance of some promising medium-duration experimental hybrids in the AICPIP coordinated trial, ICRISAT Center, rainy season 1992.**

| Entry | Days to Flower | Days to Mature | Plant height (cm) | 100-seed mass (g) | Yield ($t\ ha^{-1}$) | % Superiority over the control |
|---|---|---|---|---|---|---|
| AKPH 2080 | 94 | 136 | 183 | 11.7 | 2.34 | 106 |
| IPH 962 | 94 | 135 | 165 | 10.1 | 1.77 | 55 |
| IPH 1330 | 105 | 148 | 185 | 9.4 | 1.69 | 48 |
| Control | | | | | | |
| BDN 2 | 95 | 135 | 155 | 10.3 | 1.14 | |
| SE | ±1.9 | ±1.9 | ±5.8 | ±0.61 | ± 0.245 | |
| Trial mean (n=22) | 98.6 | 140.0 | 174.4 | 9.34 | 1.335 | |
| CV (%) | 2.7 | 1.9 | 4.7 | 9.2 | 26.0 | |

**Diversification of male sterile sources**

To transfer the male sterile gene into ICPL 83024 ($BC_2$), 87109 ($BC_3$), 87105 ($BC_2$), 87113 ($BC_1$) and 87119 ($BC_1$), the scheduled hybridization work was completed. In ALPL 33, plants of $BC_3F_1$ were harvested for raising the $BC_3F_2$ generation in the 1993 crop season.

**Development of hybrid combinations**

A total of 26 short-duration (**Table 14**) and 13 medium/late duration (**Table 15**) hybrids were made by hand pollinations. These include 13 short-duration promising hybrids which performed well in the previous season. These hybrids will be evaluated in the 1993 rainy season and part of the seed will be shared with AICPIP cooperators.

**Table 14. List of short-duration pigeonpea hybrids developed by hand pollinations, ICRISAT Center, rainy season 1992.**

| S.No. | IPH No. | Parentage | Pollinations | Seeds |
|---|---|---|---|---|
| 1 | 73[1] | ms Prabhat (DT) x ICPL 84032 | 400 | 396 |
| 2 | 575[1] | " x ICPL 87109 | 500 | 294 |
| 3 | 732[1] | ms T.21 x ICPL 87109 | 540 | 743 |
| 4 | 1213[1] | QMS 2 x ICPL 90007 | 226 | -[2] |
| 5 | 1214[1] | " x ICPL 90012 | 120 | 87 |
| 6 | 1215[1] | " x ICPL 90013 | 500 | 569 |
| 7 | 1217[1] | " x ICPL 90024 | 505 | 203 |
| 8 | 1220[1] | " x ICPL 90029 | 173 | - |
| 9 | 1223[1] | QMS 7 x ICPL 90036 | 162 | 87 |
| 10 | 1225[1] | " x ICPL 90039 | 174 | 33 |
| 11 | 1226[1] | " x ICPL 90043 | 565 | 456 |
| 12 | 1228[1] | " x ICPL 90046 | 730 | 224 |
| 13 | 1229[1] | " x ICPL 90050 | 558 | 448 |
| 14 | 1382 | QMS 2 x ICPL 90008 | 200 | - |
| 15 | 1383 | " x ICPL 90018 | 206 | - |
| 16 | 1384 | " x ICPL 91005 | 203 | - |
| 17 | 1385 | " x ICPL 91007 | 204 | - |
| 18 | 1386 | " x ICPL 91012 | 295 | - |
| 19 | 1387 | " x ICPL 91019 | 115 | - |
| 20 | 1388 | QMS 7 x ICPL 91023 | 165 | - |
| 21 | 1389 | " x ICPL 91027 | 210 | - |
| 22 | 1390 | " x ICPL 91045 | 200 | - |
| 23 | 1391 | " x ICPL 91048 | 120 | - |
| 24 | 1392 | " x ICPL 91047 | 200 | - |
| 25 | 1393 | " x ICPL 91031 | 280 | - |
| 26 | 1394 | " x ICPL 92045 | 203 | - |

1. Also made in 1991.
2. Crosses being made in the offseason in the greenhouse.

**Table 15. List of medium-duration wilt and sterility mosaic (SM) resistant hybrids developed by hand pollinations, ICRISAT Center, 1992.**

| S.No. | IPH No. | Parentage | Pollinations | Seeds |
|---|---|---|---|---|
| 1 | 1287[1] | ms ICP 3783 x ICPL 87119 | 1030 | 1161 |
| 2 | 1322[1] | " x ICPL 90100 | 1009 | 1245 |
| 3 | 1323[1] | " x ICPL 90103 | 1020 | 1550 |
| 4 | 1324[1] | " x ICPL 92001 | 1010 | 1255 |
| 5 | 1325[1] | " x ICPL 92002 | 1035 | 1810 |
| 6 | 1326[1] | " x ICPL 92003 | 1030 | 1327 |
| 7 | 1327[1] | " x ICPL 92004 | 1020 | 1110 |
| 8 | 1328[1] | " x ICPL 92005 | 1075 | 1423 |
| 9 | 1329[1] | " x ICPL 92006 | 1050 | 1263 |
| 10 | 1330[1] | " x ICPL 83056 | 1000 | 985 |
| 11 | 955 | " x ICP 11298 | 1023 | 970 |
| 12 | 1395 | " x ICPL 87051 | 1030 | 985 |
| 13 | 1396 | " x ICPL 8398 | 1060 | 1204 |

1. Also made in 1991.

**LP-304(90)IC/IC: Population enhancement in pigeonpea for diseases and insects**

**Scientists: KCJ, NBS, RPA**

**Pod borer and podfly resistance.** In both the populations harvesting was done from each male sterile plant. Seed from all the male sterile plants will be bulked for the next cycle of random mating.

## Groundnut Breeding

**LG-601(90)IC/IC: Breeding for resistance to rust and late leaf spot of groundnut**

**Scientist: LJR**

We removed volunteer plants from trials, segregating populations, and seed increase plots. We also prepared field books, recorded seedling emergence, and time to 75% flowering in trials. In the hybridization block, we removed the selfs and off-types among the $F_1$ plants. Postharvest observations for evaluation of rust and late leaf spot resistant parents are in progress.

We conducted two experiments; one to study the components of rust resistance by detached leaf technique using field grown plants, and the other to study inheritance patterns of various components of rust resistance by inoculation of potted plants in a greenhouse. Observations on lesion numbers in both the experiments were completed.

Data on oil content for 93 varieties and protein content for 32 varieties were received from the Crop Quality Unit (CQU). The oil contents ranged from 38.7 to 51.9%. ICGVs 90087, 87860, 91244, 92095, and

92103 showed >50% oil. The protein content ranged from 19.5 to 26.4%. ICGV 88256 and ICGV 87868 consistently showed >25% protein (ICRISAT Legumes Program Quarterly Technical Report, Jul-Sep 1992, p. 23).

We received data on the Fourth International Foliar Disease Resistance Groundnut Varietal Trial (IFDRGVT) conducted at the Central Agricultural Research Institute (CARI), Yezin, Myanmar (**Table 16**). Ten varieties significantly outyielded the local control Simpadetha 2. ICGV 86687 produced the highest pod yield of 1.6 t ha$^{-1}$ (compare with 0.7 t ha$^{-1}$ for Simpadetha 2). In addition to giving better pod yield, it had a much lower late leaf spot score (1.3) than that of the local control (8.0).

The two varieties ICGV 86021 and ICGV 87165 had <5% yellow plants at all growth stages when 120 genotypes were screened for resistance to yellow leaf symptoms (iron chlorosis ?) in Indonesia

**LG-602(90)IC/IC: Breeding for resistance to aflatoxin contamination in groundnut**

**Scientist: HDU**

Volunteer plans were removed from yield trials and seed increase plots We recorded preharvest observations in segregating generations and yield trials. Seed infection and seed colonization data were received from the Groundnut Pathology Unit on entries in an elite, an advanced, and two preliminary trials of the 1992 rainy season.

**Table 16. Performance of some selected varieties in the Fourth IFDRGVT at CARI, Yezin, Pylanmana, Myanmar, 1992.**

| ICGV no. | Pod yield (t ha$^{-1}$) | Rank | % over local | Days to flower | Days to harvest | Late leaf-spot[1] | Pods plant$^{-1}$ | Shelling percent-age | 100-seed mass[1] (g) |
|---|---|---|---|---|---|---|---|---|---|
| 86687 | 1.64 | 1 | 130 | 31 | 120 | 1.33 | 36 | 57 | 31 |
| 86699 | 1.42 | 2 | 100 | 33 | 121 | 1.67 | 16 | 65 | 39 |
| 86594 | 1 21 | 3 | 70 | 28 | 116 | 7.00 | 12 | 66 | 34 |
| 87280 | 1.20 | 4 | 69 | 28 | 115 | 6.33 | 11 | 68 | 42 |
| 86020 | 1.11 | 5 | 56 | 32 | 116 | 6.33 | 12 | 71 | 39 |
| 86023 | 1.09 | 6 | 54 | 31 | 117 | 4.67 | 14 | 73 | 44 |
| 86606 | 1.08 | 7 | 52 | 28 | 116 | 6.67 | 11 | 73 | 38 |
| 86652 | 1.06 | 8 | 49 | 27 | 115 | 6 33 | 12 | 70 | 43 |
| 87160 | 1.04 | 9 | 46 | 30 | 117 | 7 00 | 15 | 63 | 33 |
| 86600 | 1.03 | 10 | 45 | 32 | 115 | 6 33 | 11 | 75 | 38 |
| Control Simpa-detha 2 | 0.71 | 21 | - | 30 | 116 | 8.00 | 10 | 73 | 37 |
| SE | ±0 109 | | | ±1.7 | ±7.2 | ±0.51 | ±2.2 | ±3.2 | ±2.3 |
| Trial mean (n = 25) | 0 94 | | | 31 | 116 | 5.72 | 13 | 67 | 35 |
| CV (%) | 20 | | | 9 | 11 | 15 | 30 | 8 | 11 |

1. Scored on a 1-9 scale where 1 = no disease, and 9 = >50% foliage damaged.

In the elite trial, the range of seed infection by *Aspergillus flavus* in 18 test varieties was from 0.3 to 3.7 ± 0.40%. Ten test varieties had up to 1.1% of their seeds infected by *A. flavus* compared to 1.3% in the resistant control J 11 and 11% in the susceptible control JL 24. ICGV 86168 (0.3%) had the lowest seed infection closely followed by ICGV 88145 (0.4%) and ICGV 89104 (0.4%).

In the advanced trial, the seed infection ranged from 0.3 to 7.5 ± 0.70%. Five test varieties (ICGVs 91279, 91280, 91284, 91290, and 91304) had seed infection similar to or lower than the resistant control J 11 (0.7%). Seed colonization in the test varieties ranged from 5.2 to 28.2 ± 2.80%. Ten of these varieties had up to 8.4% of their seed colonized compared to 8.9% of the resistant control J 11 and 41.5% of the susceptible control JL 24. Five varieties (ICGVs 91278, 91280, 91283, 91290, and 91304) showed resistance to both seed infection as and seed colonization.

In a preliminary trial, the range of seed infection in 41 test varieties was from 0.3 to 8.7 ± 1.00%. Eight varieties showed seed infection similar to or less than J 11 (0.7%). ICGV 91315 had the lowest seed infection of 0.3% compared to 0.7% of J 11. In the test varieties, the seed colonization ranged from 9.1 to 89.9 ± 3.00% compared to the resistant controls in which it ranged from 9.6 to 24.1%. Eight test varieties had seed colonization similar to J 11 (13.2%). ICGV 91338 had the lowest seed colonization of 9.1%. ICGS 11, the susceptible control cultivar, showed 36.8% seed colonization.

The pod yield of the above trials has been reported in the ICRISAT Legumes Program Quarterly Technical Report, Oct-Dec 1992, p.

An elite *A. flavus*-resistant trial consisting of 25 entries was sown at Bhavanisagar in Jan 1993.

**LG-603(90)IC/IC: Breeding for resistance to groundnut viruses**

**Scientist: SLD**

**Resistance to vector**

One hundred and forty-six peanut bud necrosis disease (PBND)- resistant varieties and interspecific derivatives, identified from the 1992 rainy season, were screened for resistance to *Thrips palmi*, vector of the peanut bud necrosis virus (PBNV) at Rajendranagar farm. Thrips damage was scored on a 1-9 scale (where 1 = highly resistant, 2-3 = resistant, 4-5 = moderately resistant, 6-7 = susceptible, and 8-9 = highly susceptible) on a 43-day-old crop. Eleven varieties, ICGVs 89281, 90266, 91053, 91177, 91192, 91201, 91220, 91223, 91239, 91245, and 91249, and interspecific derivatives, 34-6-2 and CS 11 x EC 76446-34, recorded a score of 3 compared to 7 of the susceptible control, ICGV 87123. We are monitoring the development of PBND at regular intervals in these varieties. The disease incidence at present is very low.

**Resistance to virus**

Of the four PBND-resistant varieties screened for resistance to PBNV under controlled conditions in a greenhouse, ICGV 86029 and ICGV 86388 showed resistance to PBNV at $10^{-2}$ virus concentration. The disease incidence in these two varieties ranged from 15 to 17% compared with 25% in the resistant (ICGV 86031) and 78% in the susceptible (JL 24) controls. ICGV 86363 and ICGV 90071 recorded 41% and 54% BND incidence, respectively.

**LG-604(90)IC/IC: Breeding for resistance to groundnut insect pests**

**Scientist: SLD**

**Varietal performance**

Of 19 insect pests resistant groundnut varieties tested during the 1993 rainy season at the Agricultural Research Station (ARS), Darsi, Andhra Pradesh State ICGVs 86398, 86393, and 87445 recorded 44-91% greater pod yield than the local control TPT 2 (TCG 1706); ICGV 86398 being the highest yielder. TPT 2 produced a pod yield of 0.8 t $ha^{-1}$. They also showed moderate resistance (3-5 score on a 1-9 scale) to jassids. Other varieties with high degree of resistance to jassids (score 2), were ICGV 87468 and ICGV 86455. They also yielded at par with TPT-2.

**Field work**

We completed preharvest observations in the trials/segregating generations, and purified all the varieties for their morphological traits.

**LG-605(90)IC/IC: Breeding for drought tolerance in groundnut**

**Scientist: LJR**

We removed volunteer plants from the trials, segregating populations, and seed increase plots. We also prepared field books and completed labeling. We recorded seedling emergence and time to 75% flowering in the trials. In the hybridization block, we removed the selfs and off-types from among the $F_1$ plants.

We imposed mid-season drought stress in the trials and segregating material by withholding irrigation for 50 days starting from 40 days after sowing. Mortality counts were recorded by replicates in all the trials before releasing the drought stress. In the elite trial ICGV 90104 and ICGV 90129, in the advanced trial, ICGVs 86300, 87855, and 91256, and in the preliminary trial ICGVs 92112, 92129, 92130, and 92131 showed less mortality than the control varieties, ICG(FDRS) 55 and TMV 2.

The leaf samples of two breeding lines ICGV 91258 and ICGV 89416, and their parents JL 24, Kadiri 3, ICG 1697, and ICG 4790 were sent to the Crop Quality Unit for analysis of the chemical composition of leaf wax. Leaf samples were also collected from the drought stressed and nonstressed plots at 90, 105, and 120 days after sowing to determine specific leaf area.

We received from the Crop Quality Unit data on oil content for 132 varieties and on protein content for 32 varieties from the rainy season trials. The oil content in these varieties ranged from 38.1 to 55.1%, ICGVs 91254, 86263, 86300, and 86508 having >52% oil. The protein content ranged from 19.7 to 27.2%. ICGVs 90127, 90105, 90119, and 90120 showed >26% protein.

Among the 120 genotypes screened in Indonesia the foliar diseases resistant selections ICGVs 87165, 86635, and 86977 showed promise of drought tolerance.

**LG-606(90)IC/IC: Breeding for short-duration groundnut varieties**

**Scientist: HDU**

We recorded preharvest observations in yield trials and in segregating generations. Volunteer plants were removed from trials and seed increase plots. Due to low temperatures earlier in the season the crop growth was slow.

We completed harvesting of two preliminary trials at cumulative 1240 °Cd (equivalent to 75 days after sowing in rainy season at IC) and an advanced trial at 1470 °Cd (equivalent to 90 days after sowing in rainy season at IC). The elite trial was harvested at cumulative 1240 °Cd and 1470 °Cd. Almost all the plots have good plant stand and pod yields appear to be good.

Six varieties in the preliminary trials (ICGVs 92194, 92211, 92219, 92243, 92256, and 92269) and four varieties in the elite trial (ICGVs 88004, 88017, 89004, and 89024) at cumulative 1240 °Cd harvest showed maturity comparable with that of the short-duration control Chico. ICGV 92269 also has 4-week fresh seed dormancy.

In the cumulative 1470 °Cd harvest, 17 out of 31 test varieties in the elite trial and 17 out of 20 test varieties in the advanced trial showed maturity similar to Chico, and better than the national control JL 24.

We received results of oil analysis from the Crop Quality Unit on 82 varieties from elite and advanced yield trials grown under high-input conditions in the 1992 rainy season at IC. Oil contents in these lines ranged from 40.6 to 53.6%. In the elite trial, seven varieties from 1240 °Cd harvest, and 18 varieties from 1470 °Cd harvest had an oil content >50%. ICGV 89004 recorded the highest oil content (53.6%). The oil content in the national control J 11 was 50.6%.

In the advanced trial at 1470 °Cd harvest, ICGVs 89002, 89037, 91112, and 91131, had oil contents >50%.

The data on pod yields of the entries in these trials have been reported in the ICRISAT Legumes Program Quarterly Technical Report, Oct-Dec 1992, pp.20-21).

An elite short-duration trial consisting of 36 entries was sown at Bhavanisagar in Jan 1993.

**LG-607(90)IC/IC: Breeding medium-duration groundnut varieties with resistance to multiple stress factors**

**Scientist: SNN**

**Biochemical analysis**

Results were obtained from the Crop Quality Unit on oil contents of 181 varieties included in the elite, the advanced, and the preliminary yield trials, and on protein content of 96 varieties of the elite and the advanced yield trials raised in the 1992 rainy season.

The oil content in 181 varieties ranged from 41.2 to 53.5% whereas in the popular cultivars, JL 24, Kadiri 3, and ICGS 76, it ranged from 44.7 to 47.3%. Fifteen varieties had an oil content of >50%. They are ICGVs 90007 (50.0), 90013 (53.5), 90056 (50.3), 91013 (50.9), 91019 (50.8), 91024 (51.2), 91033 (50.1), 92012 (50.6), 92015 (50.9), 92026 (50.0), 92035 (51.4), 92042 (50.3), and ICG 2320 (50.3).

The protein content in 96 varieties ranged from 18.9 to 27.2%, whereas in the popular cultivars, JL 24, Kadiri 3, and ICGS 76 it ranged from 21.4 to 24.2%. Five varieties had a protein content of >25%. They are ICGVs 88312 (25.9), 89359 (27.2), 90019 (26.7), 91030 (25.4), and 91058 (26.3).

We completed recording of botanical/agronomic observations in the 1992/93 postrainy season yield trials and segregating populations. Observations on insect pest incidence are in progress. We completed purification of released and prereleased varieties and international trial entries in the seed increase block.

**Korea**

We received data on the Fourth International Medium-duration Groundnut Varietal Trial (IMGVT(SB)) from the Republic of Korea. Three varieties, ICGVs 86331, 86296, and 86289, with pod yields ranging from 4.0-4.2 t $ha^{-1}$ significantly outyielded one of the local cultivars, Shinndmk (3.3 t $ha^{-1}$). However, the pod yields of these varieties were not significantly greater than that of the best control Daekwang (3.9 t $ha^{-1}$).

### India

The medium-duration virginia bunch variety, ICGV 86325, has done well in 4 years of testing since 1989 in the All India Coordinated Research Project on Oilseeds (AICORPO) rainy season trials in Zone V. The Project Coordinator (Groundnut) has recommended its prerelease identification for the consideration of the AICORPO Special Committee on Prerelease Identification of Groundnut Varieties.

The performance of ICRISAT groundnut varieties in the front line demonstrations organized by the Zonal Coordination Unit for Transfer of Technology Projects (Zone V) for Andhra Pradesh, and Maharashtra (rainy and postrainy seasons) has been very encouraging. The general reaction of farmers in Maharashtra towards the ICRISAT varieties has been very favorable. In Andhra Pradesh the performance of ICGS 44 in the coastal sandy soils of Guntur and East Godavari Districts was excellent and farmers are enthusiastically adopting ICGS 44 in this area. In other parts of Andhra Pradesh, the farmers' responses have not been favorable in spite of high pod yields recorded by ICRISAT varieties. The main reason for this negative response as perceived by farmers is the relatively longer duration of ICRISAT varieties as compared to local cultivars such as TMV 2.

The performance of ICRISAT varieties in front line demonstrations is given in **Table 17**.

### LG-609(90)IC/IC: Breeding groundnuts for confectionery requirements

**Scientist: SLD**

**Varietal performance**

ICGV 88379 and the local control Giza 5 produced a pod yield of 2.22 t $ha^{-1}$ and were comparable in 100-seed mass (70 g) at the Ismailia Agricultural Research Station, Egypt. However, ICGV 88379 recorded the lower oil content of 48% compared with 52% of Giza 5. Other varieties with higher seed mass (86-95 g) and lower oil content were ICGV 88438 and ICGV 88391.

**Table 17. Performance of ICRISAT groundnut varieties in frontline demonstrations held in Andhra Pradesh, and Maharashtra.**

| State | Variety | Season | No. of locations | Percentage yield advantage over control cultivars (range) |
|---|---|---|---|---|
| Andhra Pradesh | ICGS 44 | Rainy 1990 | 2 | 20 - 37% |
| Andhra Pradesh | ICGS 44 | Rainy 1991 | 4 | 16 - 53% |
| Maharashtra | ICGS 11 | Rainy 1991 | 6 | 13 - 90% |
| Maharashtra | ICGS 76 | Rainy 1991 | 1 | 85% |
| Andhra Pradesh | ICGS 44 | Postrainy 1991/92 | 7 | 13 - 156% |
| Maharashtra | ICGS 11 | Postrainy 1991/92 | 13 | 25 - 141% |
| Maharashtra | ICGS 21 | Postrainy 1991/92 | 6 | 8 - 152% |
| Maharashtra | ICGS 1 | Postrainy 1991/92 | 1 | 30% |
| Maharashtra | ICGS 37 | Postrainy 1991/92 | 1 | 31% |
| Maharashtra | ICGS 76 | Postrainy 1991/92 | 1 | 62% |

**Field work**

We completed preharvest observations in the trials/segregating generations, and purified all the varieties for their morphological traits.

**Groundnut Breeding Unit - General**

We completed 18 900 pollinations covering 126 crosses in the field and 32 000 pollinations covering 160 crosses in the greenhouse to generate breeding populations for various groundnut breeding projects. We also completed 10 crosses for the inheritance study of PBNV for Ms. Hanneke Buiel, Research Scholar in the Legumes Virology Unit.

Weeding on a 4-ha field was done by the unit staff and RWF to minimize the TFL budget constraint.

## Cell Biology

**LC-051(90)IC/IC: DNA transfer to chickpea by asexual means**

**Scientists: KKS, JPM**

Work has been initiated to obtain shoots from decapitated embryo axis explants of chickpea varieties. This method is being developed for obtaining transformed shoots after co-cultivation of the decapitated embryo axis with *Agrobacterium* strains. We expect to obtain a few putative transformants which will be compared to those obtained by other means, though this method of transformation may not give high efficiencies. Work on the development of suitable regeneration systems is being carried out under a separate project.

**LC-052(90)IC/IC: Transfer of desirable traits from wild species of chickpea by sexual means**

**Scientists: NM, JPM, PSB, SVN**

*Cicer arietinum* cultivars GL 769 and ICCV 6 were crossed with annual wild *Cicer* species.

Pods were formed in all crosses except those with *C. judaicum*, (**Table 18**). A few mature seeds were obtained, and some ovules were cultured.

**LC-053(90)IC/IC: Tissue culture and regeneration of chickpea and its wild relatives**

**Scientists: NM, JPM, PSB**

An experiment to test the effect of genotype on regeneration has been initiated. Twelve elite genotypes, six each belonging to kabuli and desi varieties and four wild species of chickpea were chosen. Immature cotyledons were cultured on the regeneration medium. Differences in response have been observed.

To test the effect of cytokinins on regeneration in chickpea, kinetin, benzylaminopurine, zeatin, and thiadiazuron, a cotton defoliant having cytokinin like properties, were included individually in the culture medium. Immature cotyledons were used as explants for culture. The experiment is in progress.

Tissues from chickpea plants infected with chickpea stunt virus were cultured, and callus produced for assay for presence of the virus.

**Table 18. Interspecific crosses in Cicer, ICRISAT Center, 1992/93.**

| Cross | No. of polli-nations | Pod set (%) | No. of seeds obtained | No. of ovules cultured |
|---|---|---|---|---|
| Female parent GL 769 and male parents with ICCW number | | | | |
| *C. bijugum* (41) | 60 | 21.66 | 1 | 11 |
| *C. pinnatifidum* (38) | 80 | 7.50 | 2 | 4 |
| *C. chorassanicum* (26) | 130 | 7.69 | 1 | 0 |
| *C. cuneatum* (47) | 120 | 11.64 | 4 | 0 |
| *C. judaicum* (33) | 40 | 0.0 | 0 | 0 |
| Female parent ICCV 6 and male parents with ICCW number | | | | |
| *C. bijugum* (41) | 40 | 17.5 | 0 | 3 |
| *C pinnatifidum* (38) | 28 | 7.14 | 0 | 0 |
| *C. chorassanicum* (26) | 15 | 6.66 | 0 | 0 |
| *C cuneatum* (47) | 22 | 9.09 | 0 | 0 |
| *C. judaicum* (33) | 27 | 0.00 | 0 | |

**LP-351(90)IC/IC-01: Transfer of desirable traits from wild species of pigeonpea by sexual means**

**Scientist: NM**

Hybrid shoots obtained by the culture of immature ovules produced when an accession of *Cajanus cajan* was crossed with ICPL 87 (ICRISAT Legumes Program Quarterly Technical Report, Oct-Dec 1992, p.24) are being grown in culture on root induction media.

Crosses have been made between eight accessions of *C. platycarpa* and three accessions of *C. cajan* to test the performance of different genotypes with regard to crossability barriers.

**LP-351(90)IC/IC-02: Pigeonpea transformation by asexual means**

**Scientists : KKS, JPM**

Several experiments based on previous observations were initiated for obtaining *Agrobacterium tumefaciens* mediated transformation by using cotyledon explants following the method reported earlier. The regenerated shoots are being subcultured for their elongation. These shoots are being analyzed histochemically for presence of the GUS gene and several have shown its expression. Nontransformed shoots of seedling origin were used to test the tolerance to Kanamycin. So far, these shoots have shown tolerance to Kanamycin concentrations of up to 100 mg $L^{-1}$ without any signs of toxicity or bleaching. However, shoots grown at levels greater than 50 mg $L^{-1}$ do not show a sustained growth and fail to produce adventitious roots on a rooting medium. This shows that Kanamycin is not a very good selection agent but it does have an inhibitory effect on organogenesis from untransformed tissues, and these can be used for selection.

**LP-351(90)IC/IC-03: Tissue culture and regeneration of pigeonpea**

**Scientists: KKS, Vacant, PL**

Regeneration from longitudinal halves of stem segments from 6-day-old seedlings cultured on BA and NAA at 0 to 20 μM BA and 0 to 2 μM NAA concentrations, both alone and in combination, was repeated. Regeneration was only 8% as against 40% obtained in the first attempt. Regeneration was once again observed at 10 μM BA and 0.1 μM NAA. Based on these results, fresh cultures were initiated on 7.5 μM and 10 μM BA and 0.1 and 0.5 μM NAA combinations. All four hormonal combinations gave rise to good callus, but no morphogenesis. This callus was subcultured onto three different media compositions - L2, MS, and B5 with 0.5 mg $L^{-1}$ BA and 1 mg $L^{-1}$ IAA. L2 was best followed by MS and B5 with respect to production of green, semi-compact actively growing callus. No morphogenesis was observed. The callus obtained is now subcultured to six different hormonal combinations of 1,2,4,6,8, and 10 mg $L^{-1}$ IAA, to obtain regeneration. The rest of the callus is being maintained on 0.5 mg $L^{-1}$ BA and 1 mg $L^{-1}$ IAA.

An experiment was initiated for induction of variation by gamma irradiation. Cotyledons from 6-day-old seedlings were precultured in petri plates for 24 h on a regeneration medium. The plates were then exposed to 0.5, 1.0, 2.0, 4.0, 8.0, and 10.0 K rad irradiation and immediately transferred to fresh regeneration medium. At 0.5 K rad treatment, the percent regeneration was 94, at 1.0 K rad 78 and at 2.0 K rad 11. The regenerated shoots appear weak with long internodes and large leaves. At 4.0 K rad and 8.0 K rad proximal portion of the cotyledons necrosed, while at 12 K rad 61% necrosed at proximal portion and 39% necrosed totally. Further experiments are in progress to recover shoots for observation of any morphological variations.

In a separate experiment, of 108 in vitro regenerated somaclones transferred to the greenhouse, 77 survived. Harvesting of shoots from cultures, and their rooting and transfer to potted soil is being continued. Seeds from the greenhouse-grown somaclones are also being collected as and when formed.

**LG-651(90)IC/IC: Transfer of desirable traits from wild species of groundnut by sexual means**

**Scientists: NM, JPM**

Plant growth habit was recorded on 1 ha of interspecific derivatives ranging from early generation segregating material to advanced lines in replicated trials.

Accessions of section *Rhizomatosae* were established in pots and handed over to the Genetic Resources Unit. Plant material was provided to the Legumes Entomology Unit to screen for insecticidal activity.

Pollen stainability was scored nn 16 interspecific hybrids. Although there was no difference between hybrids of either TMV 2 or JL 24 with the amphiploid (*A. batizocoi* x *A. chacoense*), stainability was higher in the hybrid ICGMS 42 x (*A. batizocoi* x *A. chacoense*). Mean stainability was 46% with a range of 30-56%. This range of pollen stainabilities is a further evidence for intergenomic recombination in the amphiploid, which gives rise to variation in the next generation.

Chromosome pairing was analyzed at meiosis in these hybrids. Mean frequencies of univalents in the three different hybrid combinations ranged from 8.4 to 9.8 per cell, of bivalents from 8.3 to 9.0, of trivalents from 2.8 to 3.4, and of quadrivalents from 0.8 to 1.3. One pentavalent was seen in ICGMS 42 x (*A. batizocoi* x *A. chacoense*).

Pollen stainability was scored in a hybrid between accessions of section *Erectoides*. Stainability was 85%, confirming the close relationship of these accessions.

Pollen stainability in an autotetraploid of *A. cardensaii* was only 24%. This plant will be selfed and plants with high fertility selected in later generations.

The crossing program this season included the use of *A. batizocoi* x *A. chacoense* amphiploid for introgression into the Malawi lines ICGMS 30 and ICGMS 42 (67 pollinations this quarter). A similar amphiploid involving *A. batizocoi* and *A. cardensaii* was also crossed with ICGMS 42. An amphiploid involving *A. kempf-mercadoi* was crossed with Indian and Malawi cultivars and lines (167 pollinations). A tetraploid of *A. cardenasii* (84 pollinations) and diploid *A. chacoense* (35 pollinations) were also crossed with Indian and Malawi material.

Intersectional hybridization made use of amphiploids between species in section *Erectoides*. These were crossed with Indian and Malawi genotypes of *A. hypogaea* (555 pollinations). In addition, *A. batizocoi* was crossed with five species in section *Erectoides* (105 pollinations)

Most of the intersectional crosses were treated with gibberellic acid to promote peg formation.

**LG-652(90)IC/IC: DNA transfer to groundnut by asexual means**

**Scientists: KKS, JPM**

Genomic DNA was isolated from putative transformants which were earlier found to be positive for the histochemical expression of the GUS gene. The genomic DNA was restricted with ECO RI and Hind III restriction endonucleases to liberate the DNA fragment containing the GUS gene. The restricted DNA was run on a 0.8% agarose gel and transferred to nitrocellulose membrane by capillary blotting. The blotted DNA was probed with the GUS fragment labelled with digoxigenin. All the putative transformants which were earlier found to be GUS positive histochemically showed hybridization with the probe. For further confirmation, these experiments are being repeated with genomic DNA from the transformants growing in the greenhouse. Efforts are also on to confirm the presence of the npt II gene in the putative transformants by using npt II fragment for Southern hybridization and through npt II dot blot assay.

Since npt II gene has not been very useful for visual selection of the putative transformants, recently one *Agrobacterium* strain containing the GUS and hpt (hygromycin phosphotransferase) genes was obtained. Transformation experiments have been initiated with cotyledon cultures and this newly obtained construct. Separate experiments have also been initiated to test the optimal concentration of Hygromycin for selection of the putative transformants. Geneticin (G418), an analog of Kanamycin is being used to study its effect on in vitro morphogenesis to find if it can be used as a more efficient selection agent instead of Kanamycin.

The in vitro formed putative transformants were rooted and transferred to sand/vermiculite (1:1) mixture. These pots were initially maintained in a growth cabinet at 25°C with 85% humidity for about 2-3 weeks, the plants were transferred to soil mixture and maintained in the greenhouse where some of the plants have started flowering. So far, 30 plants have been transferred to the greenhouse where they are showing normal growth habit. Leaves from these plants are being harvested to carry out molecular characterization of the putative transformants. The seeds when available will also be used for molecular and genetic characterization to study the behavior of introduced genes.

**LG-653(90)IC/IC: Haploid production in groundnut, pigeonpea, and chickpea**

**Scientists: NM, Vacant**

No activity in this quarter.

**LG-654(90)IC/IC: Tissue culture and regeneration of groundnut**

**Scientists: NM, KKS, MSP**

Somatic embryos derived from immature hybrid seeds (ICRISAT Legumes Program Quarterly Technical Report, Oct-Dec 1992, p. 26) were transferred to growth medium. Embryos have grown, and some have formed multiple shoots.

**LG-655(90)IC/IC: RFLP mapping and linkage in groundnut**

**Scientist : JPM**

Plants of marker populations were maintained as cuttings in the greenhouse.

Meiosis in $F_1$ hybrids was analyzed.

Pollen stainability was scored in 20 $F_1$ plants of TMV 2 x (*A. batizocoi* x *A. chacoense* amphiploid) and in 11 plants of JL 24 x (*A. batizocoi* x *A. chacoense*). Results were similar in both hybrids. Mean stainability in the former was 39% (range 29-48%) and in the latter 38% (30-50%). Nine $F_1$ plants of TMV 2 x (*A. batizocoi* x *A. chacoense*) and 10 $F_1$ plants of JL 24 x (*A. batizocoi* x *A. chacoense*) were backcrossed to the respective cultivars and selfed to develop backcross and $F_2$ mapping populations.

## Crop Physiology

**LC-080(92)IC/IC: Development of traits to improve yield and resistance to important abiotic stress factors in chickpea**

**Scientists: CJ, NPS (reported by LKM)**

**C92/01: Evaluation of drought resistance of promising selections made for root/shoot traits and by using a conventional approach.**

This trial was sown in field BM 7B on 31 Oct. The irrigated main plots received four more irrigations on 17 Dec 1992, 6 Jan, 21 Jan, and 3 Feb 1993 besides the postsowing irrigation. Soil samples for soil moisture estimation were collected before and after every irrigation. The chickpea selections reached 50% flowering between 7 and 20 Dec 1992. Irrigation treatment was started at a time when most of the selections had reached the flowering stage, therefore, this developmental stage was not affected by irrigation. Maturation of the selections was delayed by irrigation. Under nonirrigated conditions different selections matured between 25 Jan and 6 Feb, and under irrigated conditions between 20 Feb and 2 Mar. The trial has been harvested and data recording and analysis is in progress.

**C92/02: Evaluation of drought tolerance and irrigation response of improved varieties and advanced lines from chickpea breeding**

This trial was also grown in field BM 7B and the time and number of irrigations and the soil sampling practices for soil moisture estimation was similar to that for the trial C92/01. The genotypes included in this trial reached 50% flowering between 10 Dec 1992 and 4 Jan 1993. Irrigation treatment started at 47 days after sowing, therefore it did not affect flowering time of the genotypes. Under nonirrigated condition, various genotypes matured between 23 Jan and 18 Feb and under irrigated conditions between 16 Feb and 2 Mar. The trial was harvested and data recording and analysis is in progress.

**C92/10: Evaluation of root growth dynamics of promising drought resistant chickpea selections made for root/shoot traits in relation to their parents**

The genotypes ICC 4958, Annigeri, and the progenies 5-x-4-1-x-x-x, 5-x-6-3-x-x-x, and 13-x-6-4-x-x-x reached 50% flowering at 39, 41, 40, 40, and 43 days after sowing and maturity at 83, 89, 83, 83, and 90 days after sowing in that order. Root growth was measured weekly by the minirhizotron method and fortnightly by the monolith method. Currently the measurements on the root length are being recorded using the Root Scanner. To enable root growth modeling to be done data on soil moisture, soil temperature, and dry matter production were collected periodically. The crop was harvested in the last week of Feb and the data recording on yield and yield components is in progress.

Results of the above three studies will be reported in the next Quarterly Report

**LP-405(92)IC/IC: Development of traits to enhance yield and resistance to important abiotic stress factors in pigeonpea**

**Mechanisms of drought response in extra-short-duration pigeonpea — P 92/02 (NHN, CJ, YSC)**

Studies were conducted on the effect of timing of drought stress on growth and yield of extra-short-duration pigeonpea, in continuation of experiments in the automated rainout shelter reported for 1991 (ICRISAT Legumes Program Annual Report 1991, pp. 35-36). In 1992, eight genotypes were compared at four levels of drought stress on an Alfisol. Manually-operated rainout shelters were successfully used to impose drought stress treatments during the rainy season, at the pre-flowering, flowering, and pod-fill stages.

As previously observed, drought stress at flowering reduced yield more than stress at other times (**Table 19**). This was despite soil moisture levels remaining higher in stressed plots during flowering than at other

**Table 19. Effect of timing of drought stress on grain yield (t $ha^{-1}$) of eight extra-short-duration pigeonpea genotypes, Alfisol, ICRISAT Center, rainy season 1992.**

| | | Timing of drought stress | | | | |
|---|---|---|---|---|---|---|
| Genotype | Growth habit[1] | Pre-flowering | Flowering | Pod-fill | Control | Mean |
| ICPL 83015 | DT | 2 12 | 1.50 | 2.34 | 2.40 | 2.09 |
| ICPL 84023 | DT | 1.68 | 1.65 | 2.20 | 2.46 | 2.00 |
| ICPL 88007 | DT | 1.89 | 1.59 | 2.02 | 2.12 | 1.91 |
| ICPL 89021 | DT | 1.60 | 1.72 | 2.05 | 2.01 | 1.85 |
| ICPL 87111 | IDT | 1.67 | 1.48 | 1.89 | 1.97 | 1.75 |
| ICPL 88032 | IDT | 1.38 | 1.35 | 2.06 | 2.50 | 1.82 |
| ICPL 88039 | IDT | 1.68 | 1.76 | 2.09 | 2.20 | 1.93 |
| ICPL 89002 | IDT | 1.61 | 1.32 | 1.77 | 2.07 | 1.69 |
| SE | | | ±0.142[2] | | | ±0.062 |
| Mean | | 1.70 | 1.55 | 2.05 | 2.22 | |
| SE | | | ±0.082 | | | |
| CV (%) | | | 11.3 | | | |

1. DT = determinate, IDT = indeterminate.
2. Except when comparing means with same timing of stress, where SE = ±0.123.

times. Unlike for the previously tested range of short-duration genotypes, indeterminate genotypes showed no superiority over determinate genotypes in drought resistance. Indeterminate genotype ICPL 88032 was the most sensitive genotype to drought stress at all growth stages. As in the previous year, ICPL 89021 and ICPL 88039 performed relatively better than other genotypes when stress was applied at the flowering stage. Differences in phenology could not explain genotypic differences in response to the various forms of drought stress. Studies to understand the mechanism(s) of response of extra-short-duration pigeonpea to drought stress are continuing.

**Drought response in medium-duration pigeonpea - P 91/14 (cont.) (CJ, YSC)**

A multi-environment evaluation of a set of medium-duration genotypes for performance under rainfed conditions was continued in the 1992/93 season. Rainfed and irrigated treatments were applied in field BP 7C and the set was grown only under rainfed conditions in field RP 14E. Yield data are shown in **Table 20**. In the Vertisol there was an overall 23% response to irrigation (a mild drought stress in rainfed plots). There was no overall significant genotype x irrigation response but genotypic rankings were obviously different between rainfed and irrigated treatments. Genotypes showing a drought resistant response (high intercept, low slope) were ICPLs 88047, 87119, 332, 89049, and 89051. ICPL 85063 demonstrated drought resistance with high yield potential (high intercept, high slope). ICP 8869 was particularly drought susceptible.

This set of genotypes in rainfed Alfisol yielded on average above 2 t $ha^{-1}$ (**Table 20**). ICPL 85063 was the highest yielding and ICP 8869 the lowest yielding, in conformity with their performance in this season on the Vertisol.

This data set is now being analyzed together with those obtained in previous years in order to identify genotypes with consistent drought resistance response. Such genotypes can be suggested as parents for genetic enhancement of drought resistance in medium-duration pigeonpea.

We also tested a set of breeders advance medium-duration lines for drought response in Field BP 7C. Genotypes showing drought resistance characteristics in their yield response were ICPLs 92057, 92060, and 92065 (**Table 21**). However, ICPLs 92058, 92063, and 92064 had good yield potential but were relatively more susceptible to drought stress. ICPL 92061 and ICPL 92062 performed relatively poorly in both moisture environments.

**Drought response in long-duration pigeonpea - P 92/08 (JVDKKR, CJ, YSC)**

The trial on "Response of long-duration pigeonpea genotypes to irrigation and spacing at Gwalior" was reported to be progressing well. There were some genotypic differences (visual) in the response of long-duration pigeonpea to irrigation. The trial is expected to be harvested during early April.

**Photoperiod response of short-duration genotypes - P 92/05 (YSC, CJ)**

Response of two determinate (ICPL 87 and ICPL 89021) and two indeterminate (UPAS 120 and ICPL 89002) short-duration pigeonpea genotypes to extension of natural daylength to 15 h during the 45 days following emergence was studied in an Alfisol Field (RP 17 A -South) in the 1992 rainy season. A 15 h daylength delayed time to bud initiation, 50% flowering and maturity to markedly different extents between genotypes (**Table 22**). The order of decreasing sensitivity to photoperiod was ICPL 89002, UPAS 120, ICPL 87, and ICPL 89021. The time to budding and flowering was hardly affected by photoperiod in ICPL 89021 but the time to maturity was greatly affected. Thus photoperiod appeared to increase the length of the reproductive period in this genotype; this effect was also apparent in ICPL 87 and ICPL 89002.

**Table 20. Response of grain yield (t $ha^{-1}$) to irrigation among 20 medium-duration pigeonpea genotypes in a Vertisol (BP 7C) field and yield of the same set of genotypes under rainfed conditions in an Alfisol (RP 14E) field at ICRISAT Center, 1992/93.**

| | Vertisol | | |
|---|---|---|---|
| Genotype | Rainfed | Irrigated | Alfisol |
| ICPL 8357 | 1.74 | 2.46 | 2.17 |
| ICPL 84071 | 1.62 | 2.03 | 1.87 |
| ICPL 227 | 1.90 | 2.51 | 2.25 |
| MRG 66 | 1.86 | 2.32 | 2.42 |
| ICPL 88046 | 1.74 | 2.23 | 2.23 |
| ICPL 88047 | 2.09 | 2.27 | 2.42 |
| ICPL 85063 | 1.95 | 2.66 | 2.76 |
| ICPL 85066 | 1.66 | 1.91 | 1.87 |
| ICPL 87119 | 1.98 | 2.46 | 2.25 |
| ICPL 332 | 1.94 | 2.41 | 2.03 |
| ICPL 84060 | 1.74 | 2.61 | 2.28 |
| ICPL 84008 | 1.74 | 2.43 | 2.34 |
| ICPL 89052 | 1.57 | 1.74 | 2.30 |
| ICPL 89049 | 2.01 | 2.39 | 2.29 |
| ICPL 89051 | 1.93 | 2.09 | 2.07 |
| ICPL 270 | 1.72 | 2.45 | 2.71 |
| ICP 8869 | 1.34 | 2.05 | 1.69 |
| ICPL 89046 | 1.57 | 1.95 | 1.97 |
| ICPL 89048 | 1.76 | 2.29 | 2.23 |
| C 11 | 1.84 | 2.50 | 2.37 |
| Mean | 1.78 | 2.29 | 2.23 |
| SEM for main plot | 0.022 | | 0.208 |
| SEM for sub plot | 0.108 | | |
| SEM for main x sub plot | 0.150 | | |
| SEM for main x sub plot with same level of main plot | 0.152 | | |
| CV (%) | 12.9 | | 16.2 |

The effect of extended photoperiod in delaying phenology was reflected in greater vegetative growth, in terms of aerial biomass, plant height at 50% flowering and at harvest, number of main stem nodes and number of primary branches (data not shown). However, grain yields were markedly reduced by extended photoperiod in all genotypes, but less so in ICPL 89021 (**Table 22**). This may have in part been contributed to by the higher pod borer infestation under extended daylength compared to natural daylength (50% versus 20% pod damage, approximately).

The present results demonstrate extreme sensitivity of phenology, growth, and yield of short-duration pigeonpea to daylength and strong genotype x photoperiod interactions within this maturity group. In this study, the indeterminate genotypes were much more sensitive to photoperiod than the determinate ones. The basis of these effects and interactions needs further understanding if we are to eventually be able to predict performance of short-duration pigeonpea across latitudes and consequently establish optimum management systems (e.g., the effect of photoperiod on plant height and harvest index).

**Table 21. Response of grain yield (t $ha^{-1}$) to irrigation of 10 breeders' advanced medium-duration pigeonpea lines in a Vertisol (BP 7C) field at ICRISAT Center, crop season 1992/93.**

| Genotype | Rainfed | Irrigated | Mean |
|---|---|---|---|
| ICPL 92056 | 1.83 | 2.32 | 2.08 |
| ICPL 92057 | 2.05 | 2.70 | 2.37 |
| ICPL 92058 | 1.66 | 2.41 | 2.03 |
| ICPL 92059 | 1.81 | 2.74 | 2.28 |
| ICPL 92060 | 2.27 | 2.20 | 2.23 |
| ICPL 92061 | 1.54 | 2.06 | 1.80 |
| ICPL 92062 | 1.68 | 2.18 | 1.93 |
| ICPL 92063 | 1.77 | 2.60 | 2.19 |
| ICPL 92064 | 1.68 | 2.65 | 2.17 |
| ICPL 92065 | 1.94 | 2.37 | 2.16 |
| Mean | 1.82 | 2.42 | |
| SEM for main plot | 0.012 | | |
| SEM for sub plot | 0.090 | | |
| SEM for main x sub plot | 0.121 | | |
| SEM for main x sub plot with same level of main plot | 0.127 | | |
| CV (%) | 10.3 | | |

**Table 22. Response of phenology (days after sowing) and grain yield (t $ha^{-1}$) of four short-duration pigeonpea genotypes to daylength extended to 15 h (E), as compared with natural daylength (N), in an Alfisol (RP 17A) field at ICRISAT Center, rainy season 1992.**

| | Bud initiation | | 50% flowering | | Maturity | | Grain yield | |
|---|---|---|---|---|---|---|---|---|
| Genotype | N | E | N | E | N | E | N | E |
| ICPL 87 | 53 | 69 | 78 | 102 | 125 | 180 | 2.00 | 0.91 |
| ICPL 89021 | 49 | 51 | 68 | 70 | 109 | 139 | 1.92 | 1.52 |
| UPAS 120 | 54 | 83 | 81 | 121 | 142 | 187 | 1.96 | 0.92 |
| ICPL 89002 | 50 | 83 | 79 | 129 | 116 | 195 | 2.12 | 1.21 |
| SE | ±0.8 | | ±3.9 | | ±10.0 | | ±0.209 | |
| CV (%) | 2.8 | | 9.7 | | 11.5 | | 21.7 | |

**Interaction of growth habit and insect damage in short-duration pigeonpea - P 92/04 (YSC, CJ, CSP)**

In this collaborative study with the Legumes Entomology Unit, indeterminate (UPAS 120 and ICPL 85045) and determinate (ICPL 87 and ICPL 86012) genotypes were compared for their response to plant protection (insecticide spraying) from pod borer damage. Earlier, such studies had indicated that ICPL 86012, in addition to its good ratoonability, was better able to withstand insect damage to the first flush, as compared to ICPL 87 and indeterminate genotypes. This repeat study was conducted on an Alfisol (RP 14 E) and a Vertisol (BP 7C) in the 1992/93 season, under irrigated conditions so as to obtain a second flush of pods.

*Helicoverpa* pod borer damage to the first flush in the nonsprayed treatment was severe, and although ICPL 86012 did yield more than other genotypes, the yield was negligible (i.e., this genotype was also devastated by pod borer) (**Table 23**). There was good yield compensation in the second flush in nonsprayed plots, but ICPL 86012 performed poorest in this regard. This is in contrast to earlier findings of good ratoonability in ICPL 86012. Also, although ICPL 86012 held up well under moderate pod borer attack, it had no advantage under severe attack. Further investigations are needed to understand the apparent contrasting responses of ICPL 86012 between years.

**Effect of shading at different growth stages on extra-short-duration pigeonpea - P 92/03 (NHN, YSC, CJ)**

In combination with the portable rainout shelter study on effect of drought stress applied at different times to eight extra-short-duration pigeonpea genotypes (P 92/02), a study on effect of shading by these shelters in their parking places was conducted. Thus shading at the pre-flowering, flowering and pod-filling stages was compared with no shading for the same eight genotypes.

Shading at the flowering stage, like drought stress at that stage, significantly reduced yield compared to the other treatments (**Table 24**). There was no apparent genotype x shading interaction. Thus study confirms the vulnerability of the flowering stage in pigeonpea to stress in general (in this case reduced light intensity).

**Effect of differential levels of soil moisture at the time of sowing on growth and yield of extra-short-duration pigeonpea - P 92/06 (NHN, YSC, CJ)**

Earlier studies (e.g., those by Dr K. Okada in Phase I of the GOJ Project) had indicated that a possible reason for the marked decline of extra-short-duration pigeonpea yields following delay in sowing beyond the longest day was excessive soil moisture conditions during the vegetative growth stage. To test this hypothesis, the following treatments were applied in a split plot design to extra-short-duration genotype ICPL 84023 in both an Alfisol (RP 14 E) and a Vertisol (BP 7A) field:

- Main plot: date of sowing - 15 June, 5 July, 25 July, 15 Aug
- Sub-plot: soil moisture status - dry (soil covered by polythene sheeting prior to sowing)
  - charged soil profile (by rain and/or irrigation)
  - Charged soil profile with polythene in furrows after sowing (to decrease infiltration).

An uncharged profile at sowing benefitted yield only at the final sowing in the Alfisol and for the last two sowings in the Vertisol (**Table 25**). This was despite beneficial effects of the initial dry profile on early vegetative growth at the early sowings. However, other factors, such as temporary water deficit, appeared to have negated these early growth responses. The data thus give some support to the contention that late-sown extra-short-duration genotypes fail to produce sufficient biomass due to excess soil moisture conditions. However, further detailed confirmatory studies are needed, with more rigorous control and monitoring of soil water status throughout the growing period.

**Table 23. Response of first and second flush grain yields (t ha⁻¹) of four short-duration pigeonpea genotypes differing in growth habit to protection from pod borer damage by insecticide spraying. Experiments were conducted on an Alfisol (RP 14 E) and a Vertisol (BP 7C) field at ICRISAT Center, crop season 1992/93.**

| Genotype | First flush | | Second flush | |
|---|---|---|---|---|
| | Sprayed | Nonsprayed | Sprayed | Nonsprayed |
| **Alfisol** | | | | |
| UPAS 120 | 2.03 | 0.15 | 0.99 | 1.57 |
| ICPL 85045 | 1.91 | 0.22 | 0.60 | 0.99 |
| ICPL 87 | 2.29 | 0.02 | 0.90 | 1.67 |
| ICPL 86012 | 2.17 | 0.22 | 0.53 | 0.87 |
| SE | ±0.088 | | ±0.110 | |
| CV (%) | 9.7 | | 21.2 | |
| **Vertisol** | | | | |
| UPAS 120 | 1.59 | 0.09 | 0.89 | 1.01 |
| ICPL 85045 | 2.02 | 0.04 | 0.51 | 1.45 |
| ICPL 87 | 1.91 | 0.004 | 0.68 | 1.14 |
| ICPL 86012 | 1.61 | 0.12 | 0.41 | 0.80 |
| SE | ±0.069 | | ±0.094 | |
| CV (%) | 16.9 | | 19.1 | |

**Table 24. Effect of shading at different growth stages on grain yield of eight extra-short-duration pigeonpea genotypes in an Alfisol (RCE 3) field at ICRISAT Center, rainy season 1992.**

| Genotype | Shading treatment | | | | |
|---|---|---|---|---|---|
| | Preflowering | Flowering | Podfill | No shading | Mean |
| ICPL 83015 | 2.35 | 2.06 | 2.42 | 2.43 | 2.32 |
| ICPL 84023 | 2.18 | 1.94 | 2.05 | 2.25 | 2.11 |
| ICPL 88007 | 2.22 | 1.84 | 2.04 | 2.31 | 2.10 |
| ICPL 89021 | 2.09 | 1.61 | 1.84 | 2.08 | 1.90 |
| ICPL 87111 | 2.33 | 1.87 | 2.05 | 2.13 | 2.10 |
| ICPL 88032 | 2.16 | 2.02 | 2.26 | 2.13 | 2.14 |
| ICPL 88039 | 2.32 | 1.93 | 2.19 | 2.32 | 2.19 |
| ICPL 89002 | 2.07 | 1.91 | 1.98 | 2.13 | 2.02 |
| SE | | ±0.122 | | | ±0.061 |
| Mean | 2.22 | 1.90 | 2.11 | 2.22 | |
| SE | | ±0.047 | | | |
| CV(%) | | 9.9 | | | |

**Table 25. Effect of differential levels of soil moisture at sowing on grain yield of ICPL 84023 sown at different times on Alfisol (RP 14E) and Vertisol (BP 7A) fields at ICRISAT Center, rainy season 1992.**

| Treatment | 15 Jun | 5 Jul | 25 Jul | 15 Aug | Mean |
|---|---|---|---|---|---|
| | Sowing date | | | | |
| | | Alfisol | | | |
| Dry profile | 1.81 | 1.31 | 1 14 | 1 66 | 1 48 |
| Charged profile | 1.87 | 1 39 | 1.11 | 1.38 | 1.44 |
| Charged + row cover | 1.77 | 1 53 | 1 24 | 1.37 | 1.48 |
| SE | | +0 068 | | | +0.036 |
| Mean | 1.82 | 1 41 | 1 16 | 1 47 | |
| SE | | +0 032 | | | |
| CV (%) | | 8.6 | | | |
| | | Vertisol | | | |
| Dry profile | 1.18 | 0.52 | 1.13 | 1.23 | 1.01 |
| Charged profile | 1.16 | 0.87 | 0.92 | 0 98 | 0.98 |
| Charged + row cover | 1.34 | 1 00 | 0 88 | 0 86 | 1.02 |
| SE | | +0.097 | | | +0.032 |
| Mean | 1.22 | 0.80 | 0.98 | 1.02 | |
| SE | | ±0.083 | | | |
| CV (%) | | 10.9 | | | |

**Effect of sowing date on phenology, growth and yield of short-duration pigeonpea genotypes - P 92/01 (NVL, YSC, CJ, SMV)**

This is a joint study with the Resource Management Program (RMP)-Agronomy (Agroclimatology) designed to obtain the necessary data to develop a crop model for short-duration pigeonpea. Four genotypes (ICPLs 89021, 84023, 88034, 87) were sown in an Alfisol field at monthly intervals from 15 Apr 1992 to 15 Feb 1993 and growth analysis was conducted on each crop. The study is still in progress and results will be reported after analysis.

**LG-704(92)IC/IC: Identification of genotypic traits for resistance to abiotic stress factors in groundnut**

**Scientist: RCNR**

In the drought screening experiment, mid- and end-of-season droughts were imposed and required data recorded as per the schedule. Data on specific leaf area (SLA) were collected on 2000 groundnut germplasm accessions which are being grown by the Genetic Resources Unit (GRU) in a replicated trial during the current season.

**Genotype x soil acidity x drought interactions**

During 1992, under the CLAN-funded collaborative project, an experiment was conducted at the Sukarami Research Institute for Food Crops (SARIF), Sitiung, Indonesia to examine genotype x soil acidity x drought interactions in groundnut.

Since the primary effect of soil acidity is to inhibit root growth, occurrence of even mild drought on acid soils can accentuate the drought effect on the crop. Preliminary studies conducted under ACIAR's project on "Peanut Improvement in Indonesia" indicated that some of the drought-tolerant selections from ICRISAT also showed some acid soil tolerance. But genotypic response to the combined effect of soil acidity and drought is not known. The present study was conducted to examine performance of some selected drought-tolerant groundnut genotypes under irrigated and rainfed conditions on acid soils. Eight selected groundnut genotypes were grown at 5 levels of lime i.e., 0, 0.5, 1, 2, and 3 t $ha^{-1}$, each under irrigated and rainfed conditions. The lime was applied as a presowing dose at the time of land preparation. The treatments were replicated three times. During the season there were brief dry spells. Consequently, the irrigated treatment received irrigation (by flood) at 3, 6, 7, 9 and 10 weeks after sowing.

The total dry matter production in general was very low (mean = 12.8 g $plant^{-1}$) at the '0' lime level but increased to 52 g $plant^{-1}$ (data on $m^{-2}$ basis is awaited) with application of lime at 0.5 t $ha^{-1}$. Further addition of lime up to 3 t $ha^{-1}$ did not significantly enhance the total dry matter. There was only a marginal difference in total dry matter between irrigated and rainfed treatments at '0' lime level. Pod dry matter was reduced by 50% under rainfed conditions at the '0' lime level. Addition of lime at 0.5 t $ha^{-1}$ enhanced pod yield from 11 to 42 g $m^{-2}$. Increased dosage of lime from 0.5 to 3 t $ha^{-1}$ enhanced pod yields from 42 g to >60 g $m^{-2}$. Harvest index was however, very low (0.07 - 0.08) at '0' lime level and increased to only to 0.12 with addition of 3 t $ha^{-1}$ of lime. These results suggested that there might be factor(s) other than soil acidity (through $A1^{+++}$ saturation) affecting partitioning of dry matter to pods. Low irradiation (14-16 Mj $m^{-2}$) and high humidity at Sitiung also might be playing a role in reducing partitioning, which requires further investigation.

The analysis of variance for total dry matter and pod yield (**Table 26**) showed that:

a) The lime application had a significant effect on total dry matter production. The effect of irrigation was significant ($P<0.01$) and there was liming x irrigation interaction on total dry matter ($P<0.05$). The genotypes differed significantly in total dry matter ($P<0.01$) and the interaction of liming and genotypes was significant ($P<0.01$).

b) Analysis of pod yield showed that the effect of liming was significant ($P<0.01$) on pod dry matter and genotypes differed significantly for pod dry matter. The interactions of lime, irrigation and genotypes, however, were not significant.

There was no genotypic variation for total dry matter at '0' lime application, while the genotypic variation was apparent in total dry matter production at 0.5 t $ha^{-1}$. ICGV 86644 and ICGV 86635 (which were identified as drought tolerant at IC) also showed 10-15% superior total dry matter production at 0.5 t of lime $ha^{-1}$ compared to the best local controls. However, the pod yields of these two genotypes were not significantly higher than those of the local controls. The data will be further analyzed after receiving more information about weather and crop data from the collaborating scientists at SARIF, Indonesia.

**Table 26. Analysis of variance and mean sum of squares for total dry matter and pod yield of eight groundnut genotypes grown on acid soil at Sitiung, Indonesia, 1992.**

| Source of variation | Df | Adjustable biomass | Pod weight |
|---|---|---|---|
| Replication | 2 | 11.5 | 3.1 |
| Main lime rate (L) | 4 | 9763** | 16887** |
| Irrigation (IR) | 1 | 736** | 1494** |
| IR x L | 4 | 76.4* | 83.6 |
| Genotypes (G) | 7 | 70.4** | 262** |
| L x G | 28 | 7.4** | 53.5 |
| IR x G | 7 | 0.9 | 34.0 |
| L x IR x G | 28 | 2.9 | 22.9 |
| Error | 140 | 2.4 | 46.6 |
| CV (%) | | 4.1 | 17.8 |

**LL-919(92)IC/IC Agroclimatic and genotype x environment analysis of chickpea, pigeonpea, and groundnut**

The workshop held at ICARDA, Aleppo, Syria, on "Adaptation of chickpea in WANA" was reported in the International Chickpea Newsletter 27, p. 5. Editing of papers and correction of GIS maps are continuing.

For presentation at the Asian Grain Legumes On-farm Research (AGLOR) Workshop at Ho Chi Minh City, Vietnam in February, data on groundnut area, production, and yield in Vietnam and on climatic factors were entered on the GIS (collaboration with RMP - Agroclimatology). Further data are being collected for the study on "Agroclimatology of groundnut in Vietnam".

**LL-920(92)IC/IC: Enhancing nitrogen fixation in legumes**

**Scientists: OPR, JVDKKR**

**Assessing nitrogen fixed by chickpea lines (OPR)**

Methods based on use of the $^{15}N$ isotope are considered as most dependable for measuring the amount of nitrogen fixed by plants. The high cost of $^{15}N$ chemicals and of analyzing plant samples for $^{15}N$ have prevented us from undertaking such studies on our own. In the early to mid 1980s, we collaborated with scientists of the Rothamsted Experimental Station, for about 4 years, on using $^{15}N$ based methods to assess biological nitrogen fixation (BNF) by our mandate legumes. We again began similar collaborative activities in early 1991 - this time with the International Atomic Energy Agency (IAEA), Vienna, Austria and the National Agricultural Research Center, Tsukuba, Japan. Results of $^{15}N$ analysis of a field trial conducted at Gwalior in 1987 arrived recently from our two collaborators. IAEA analyzed the samples from $^{15}N$ enrichment plots and the samples from normal $^{14}N$ plots were analysed by Dr T. Yoneyama of NARC, for presence of $^{15}N$ in plant samples that they acquired from the $^{15}N$ present naturally in soil. A draft paper on this work was recently completed for inviting inputs of the scientists involved with these studies. Results are summarized below.

Six chickpea cultivars representing a range of nodulation capability were grown on an Inceptisol to assess the amount of BNF. Two $^{15}N$ based methods, A-value and $\delta^{15}N$, were used for this assessment. A nonnodulating chickpea selection from one of the six test cultivars was used as a reference line. Crop growth of all the entries was normal and most cultivars, including the reference line supplied with 50 kg N $ha^{-1}$, produced over 5 t $ha^{-1}$ dry matter and about 2 t $ha^{-1}$ grain yield. Total nitrogen yield of the six different cultivars ranged from 88 kg $ha^{-1}$ by ICCC 42 to 110 kg $ha^{-1}$ by Annigeri. Nodulation was generally low but the high nodulating cultivar K 850 produced maximum nodule mass at all the four sampling times and had maximum ARA values when measured at 64 DAS. The nonnodulating reference line ICC 435 M supplied with 50 kg N $ha^{-1}$ had very similar plant growth pattern (**Fig. 2**) to its normal nodulating parent line ICC 435, a requirement for a perfect reference crop, and also yielded similar quantities of dry matter and grain. Under these conditions 25 to 38% of the plants' N was derived from the atmosphere when measured by the A-value method and 17 to 29% N when measured by the $\delta^{15}N$ method. K 850 was assessed to have derived the highest proportion as well as amount of N from air when assessed by both the methods. In other cultivars amounts of N from air ranged from 17 to 30 kg $ha^{-1}$ (**Fig. 3**). High mineral N in soil seemed to be a plausible reason for low percentage N derived from air, or low BNF.

In addition to the high mineral N in soil that suppressed nodulation and therefore reduced the amounts of nitrogen fixed by different chickpea lines (**Fig. 3**), low values may also be at least partly due to the $^{15}N$ methodology artifacts. Perhaps the estimates of $N_2$-fixation become more variable and are therefore less dependable where fertilizer use efficiency is low. Fertilizer use efficiency was <2% in case of nodulated and about 10% in case of nonnodulated chickpea lines. Discussion with researchers having long experience on $^{15}N$ methodologies indicated that assessments obtained from experiments conducted on a soil profile charged with enriched $^{15}N$ should be most dependable. We have therefore initiated development of such a long term plot in field BP 2C in the postrainy season 1992/93 in collaboration with IAEA. This should allow us to screen genotypes recently identified for a range of nodulation capacity from within different cultivars of chickpea and pigeonpea.

**Genotypic variation for % N derived from fixation in pigeonpea (JVDKKR)**

In the trial **P 92/09 'Genotypic variation in short-duration pigeonpea in the proportion of N in the plant derived from atmospheric nitrogen fixation using a $\delta^{15}N$ technique'** the long-duration pigeonpea genotypes and the long-duration sorghum (used as one of the non-fixing controls) were harvested and yields were recorded from both Alfisol and Vertisol fields. About 150 grain samples of extra-short, short-, medium-, and long-duration pigeonpea genotypes along with those of non-fixing controls, namely, maize, pearl millet, hybrid sorghum, and long-duration sorghum, were ground and digests were made for total N and $^{15}N$ determinations, the latter to be arranged in Dr T. Yoneyama's laboratory in Japan. An associated pot culture study to determine the $\delta^{15}N$ of symbiotically dependent pigeonpea genotypes revealed that the *Rhizobium* strain IC 3195 used for the study was ineffective. This was rather surprising as IC 3195 used to be an effective and a standard *Rhizobium* strain for inoculating pigeonpea. We are trying to sort out this. Meanwhile the pot culture study has been repeated using a different *Rhizobium* strain, IC 3100. The plant samples were ground and digested for $\delta^{15}N$ determination. Preliminary results of $\delta^{15}N$ of some of these samples, sent by Mr T.P. Rao who is presently at Dr T. Yoneyama's laboratory in Japan, are highly

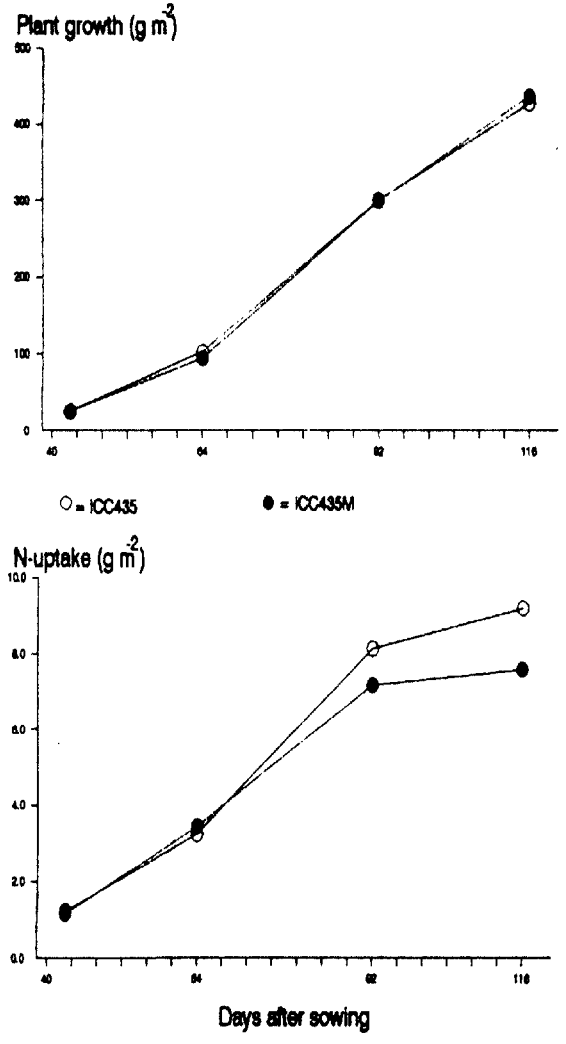


*Figure 2. Plant growth (above ground matter) and N-uptake pattern of nodulating (ICC 435) and nonnodulating (ICC 435M, supplied with 50 kg N ha-1) chickpea lines, Gwalior, postrainy season 1987/88.*

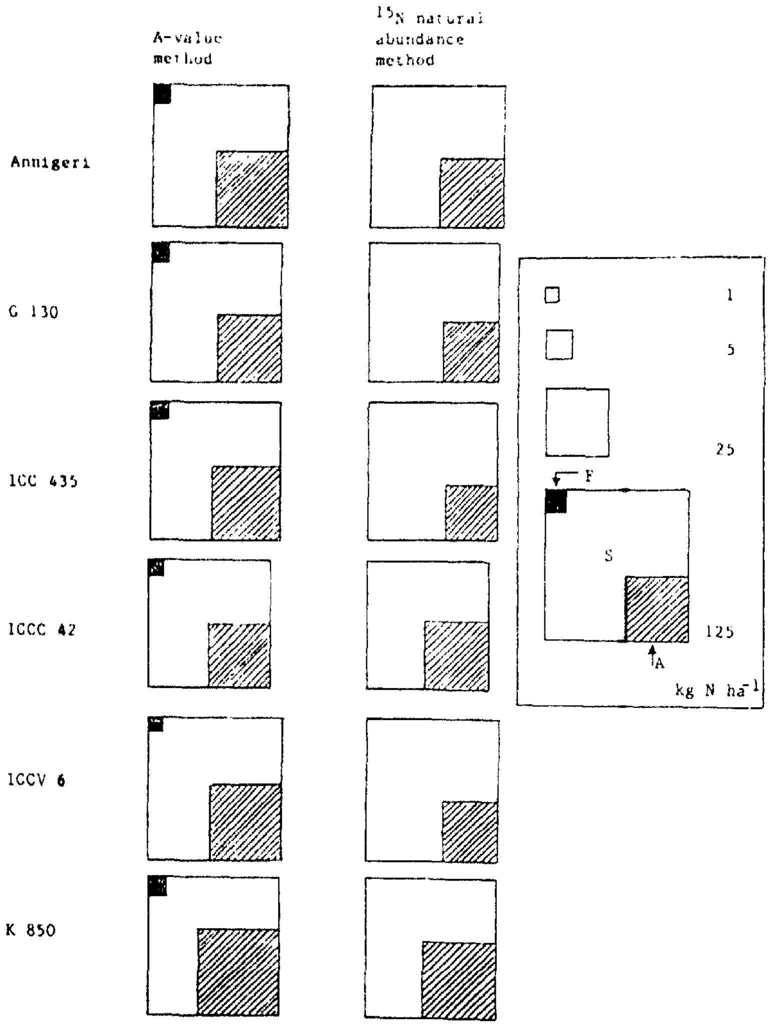


*Figure 3. Amounts of nitrogen fixed by six chickpea cultivars as assessed by two $^{15}N$ based methods, Gwalior, postrainy season 1987/88. (Each square reflects the amount of nitrogen taken up by plants. Squares with 1, 5, 25, and 125 kg N $ha^{-1}$ in the inset are given to assist quantification. A, F, and S represent nitrogen from atmosphere, fertilizer, and soil, respectively).*

promising. Using the $\delta\ ^{15}N$ method we hope to detect genotypic differences in % Ndfa by pigeonpea as influenced by maturity group and also soil type.

The single plant progeny of ICPL 84032, selected for its relatively poor growth and chlorotic leaves (putative non-nodulating) under field conditions, when tested in the greenhouse indicated large variation for nodulation:non-nodulating, low- nodulating (2 nodules $plant^{-1}$) and high-nodulating (15 nodules $plant^{-1}$). These single plant selections are being maintained in the greenhouse for seed production. If the non-nodulating selections are consistent in subsequent generations then they would be useful as non-fixing controls for measurement of $N_2$ fixed by short-duration pigeonpea.

**LL-918(90)IC/IC: Nitrogen dynamics of pigeonpea, groundnut, and chickpea in relation to root distribution, soil water status, and cropping system**

**Scientists: OI,KK,JJAG - GOJ Special Project**

**Modeling of root system development based on soil physico-chemical properties, climatic data, and dry matter allocation to roots**

**Objectives and Introduction**

In the Oct-Dec 1992 Quarterly Report (pp. 34-38), a simple approach to summarize the profile data of root length density was presented. This has proved to be useful when dealing with data sets as in the case of observations on trench walls which give two dimensional images of root profiles. However, this kind of approach is only effective in fitting real data into a certain equation for simplification purposes. It hardly allows further prediction of rooting profile under the modified conditions with slightly different soil strength, temperature regime and so on. For this purpose, a concrete model for root systems should be established. The model should predict various root characters from climatic data, soil characteristics, and plant genetic variables.

As the first step to develop such a model, a model which has appropriate functions and outputs from the viewpoint of our entire project was searched for and modified to be operative with limited data sets available from our field experiments. Then the model was evaluated by comparing its output with the obtained data.

**Model Principle**

To study and model the root behavior, an initial exercise had been performed using a modification of an existing root model (Jones et al. 1991). Several static and dynamic stress factors affect root growth. Certain static stress factors such as aluminum toxicity, calcium deficiency, coarse fragments, qualitative constraints, and dynamic stress factors such as soil strength, aeration, and temperature are incorporated into this model. Soil water content and temperature change dramatically during the cropping season and hence their effect on the root system should be estimated regularly. Studies have shown that root growth has an approximately linear relation with soil strength and is sensitive to soil aeration. The low soil temperature may limit root growth. In the model, effects of both static and dynamic parameters on root growth are expressed as stress factors, which range in value from 0 (no growth) to 1.0 (no stress). The model then simulates four processes that determine root distribution in the soil, such as (i) increasing depth of the rooting front; (ii) the length/mass ratio of new roots; (iii) proliferation within soil layers; and (iv) senescence.

**Model Structure**

The model (ROOT92.FOR) consists of two stages. The first stage (Stage I) is for the simulation of dynamic factors such as moisture content and mean soil temperatures in soil layers which directly affect the root growth. The simulation is carried out for volumetric water content with Ritchie's multi-layered water balance model (WATBAL.FOR) and for temperatures with sub-routine SOLT from CERES-Maize model (SOLTJUN.FOR), at the centers of given layers on a daily basis. The second stage (Stage II) is to use these data sets for the root simulation along with soil profile characteristics (DSSAT 3.0), the simulated dry matter allocation to the root and genetic characteristics Final outputs from ROOT92.FOR are rooting depth, growth and death of roots, length/mass ratio, and root length density by soil layer on a daily basis. The flow diagram of the whole exercise is shown in **Fig. 4**. The source codes for the model are written in Fortran.

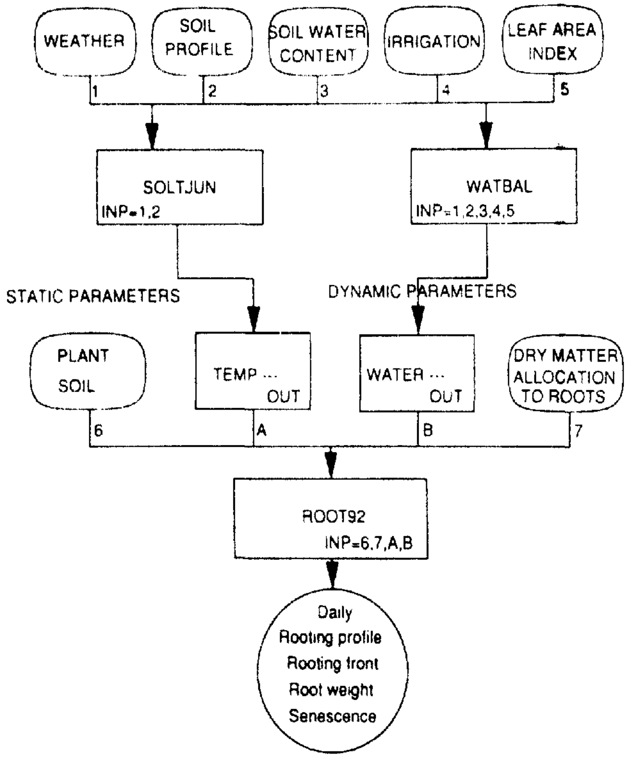


*Figure 4. Flow diagram of the model.*

## Model Input

### Input for Subroutine

In order to simulate the daily moisture content in each soil layer with WATBAL, data sets of weather, soil characteristics for each layer, irrigation schedule, measurements such as initial water content in the soil profile, leaf area index at various growth stages are required (**Table 27**). To estimate daily soil temperature for each layer with SOLTJUN, weather data, bulk density of soils and plant extractable soil moisture content which can be obtained from output of WATBAL should be given.

### Input for ROOT92

Certain genetic parameters of plants and static parameters for the soil profile are necessary for the operation of the root model. Some of them had to be taken from published literature as they were not available due to the complexity of the processes involved for measuring the required parameters. Details of the inputs are given in **Tables 28 and 29**.

As one of the important dynamic parameters, the model requires dry matter allocation from shoots to root on a daily basis. Since it is entirely impossible to collect such frequent data from the field, a simulation was carried out using a limited number of data points of dry matter accumulation within plants during the whole growth period. A few data sets of root/shoot ratios were fitted to an exponential equation based on the observation by Thornley (1977) Using equations for growth curve and root/shoot ratio, daily dry matter allocation to roots was calculated. Soil moisture content and soil temperature, the other dynamic parameters were simulated using the WATBAL and SOLTJUN routines.

**Table 27. Details of input items for operation of the whole model.**

| No | Item | Component |
|---|---|---|
| 1 | daily weather data<br>temp. and rainfall | solar radiation, maximum & minimum |
| 2 | soil profile characteristics<br>upper limit & lower<br>and root growth | saturated water content, drained<br>limit of plant extractable water<br>distribution factor |
| 3 | initial soil water content | |
| 4 | amounts of irrigation applied | |
| 5 | leaf area index | |
| 6 | plant & soil characteristics | see Tables 2 & 3 |
| 7 | dry matter allocation to roots | see text |
| A | mean soil temp. | from SOLTJUN |
| B | volumetric water content | from WATBAL |

**Table 28. Genetic characteristics of plants to be input for operation of ROOT92 model.**

| Abb. | Description | Input |
|---|---|---|
| RDX | normal maximum root system depth (m) | 2.5 |
| GSR | growth stage when root depth reaches maximum | 0.7 |
| LWM | normal ratio of root length to weight in plow layer at maturity (m $g^{-1}$) | 75.0 |
| LWS | normal ratio of root length to weight in seedling (m/g) | 75.0 |
| WCG | weighting coefficient -geotropism- | 3.0 |
| TBS | base temperature for root growth (C) | 8.0 |
| TOP | optimum temperature for root growth (C) | 25.0 |
| CAA | calcium saturation below which root growth is reduced (%) | 15.0 |
| CAX | calcium saturation below which root growth is negligible (%) | 0 |
| ALA | aluminum saturation below which root growth is unaffected (%) | 43.0 |
| ALX | aluminum saturation above which root growth is negligible (%) | 90.0 |
| PD | planting depth (m) | 0.05 |
| GSD | growth stage when normal root senescence begins | 0.9 |
| SFT | fraction of normal root growth when pore space is saturated (0-1) | 0 |

**Table 29. Physico-chemical characteristics of soils to be input for operation of ROOT92 model.**

| Z | BD | SAN | SIL | ROK | SMB | EAL | CA | UL | LL | SCD |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | 1.50 | 81.8 | 7.6 | 0.06 | 58.6 | 0.90 | 31.1 | 0.156 | 0.049 | 1.0 |
| 0.10 | 1.62 | 81.8 | 7.6 | 0.06 | 58.6 | 0.90 | 31.1 | 0.156 | 0.049 | 1.0 |
| 0.20 | 1.71 | 80.7 | 7.6 | 0.08 | 62.3 | 0.50 | 33.5 | 0.160 | 0.050 | 1.0 |
| 0.30 | 1.74 | 77.4 | 7.2 | 0.09 | 96.3 | 0.60 | 46.6 | 0.175 | 0.055 | 1.0 |
| 0.40 | 1.72 | 72.5 | 6.7 | 0.27 | 147.3 | 1.10 | 70.7 | 0.195 | 0.105 | 1.0 |
| 0.50 | 1.77 | 68.2 | 7.2 | 0.44 | 175.7 | 2.70 | 76.2 | 0.174 | 0.099 | 1.0 |

Z : depth (m)
BD : bulk density
SAN : sand (%)
SIL : silt (%)
ROK : coarse fragment as fraction of soil volume (0-1)
SMB : sum of bases (cmol $kg^{-1}$)
EAL : extractable aluminum (cmol $kg^{-1}$)
CA : exchangeable calcium (cmol $kg^{-1}$)
UL : drained upper limit of soil water for the fine earth fraction (m $m^{-1}$)
LL : lower limit of plant-extractable soil water for fine earth fraction (m $m^{-1}$)
SCD : code set to 0 to stop root growth if the horizon is Duripan, Fragipan, Lithic, Paralithic, Petrocalcic, Petroferric, Petrogypsic, or Skeletal and to 1.0 if other or not known

**Model Output**

The exercise was carried out with the data sets from the N2 treatment in the sorghum monocrop during the 1991 rainy season. At the end of Stage I, the simulated volumetric water content at the centers of five different layers were obtained and were graphically plotted along with the observed values for each of the layers separately during the season (**Fig. 5**). It can be observed from the figure that the simulation gives almost the same trend as the gravimetrically obtained data. At a glance, the observed values in almost all the layers seem to be higher than the simulated values. This could be due to inappropriate setting of the drained upper limit and lower limit of plant extractable water, or to the inaccuracy of the initial soil water content in the layers. The rainfall reflects the water content in all the layers, whereas irrigation has negligible effect on water content in the bottom layers, indicating insufficient amount or unsuitable methods of irrigation. It should be noted that the observed values are at periodic intervals but the simulated values are on a daily basis.

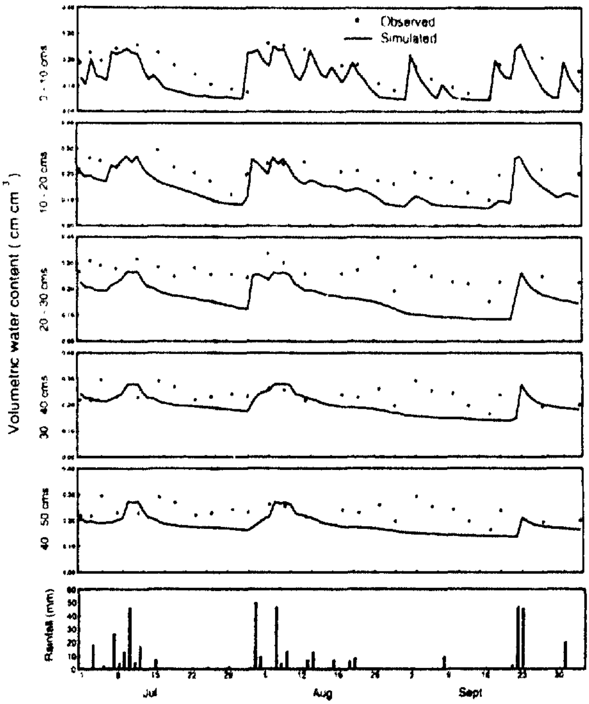


*Figure 5. Volumetric water content of soils at the upper five layers (10 cm interval) obtained by actual measurement and simulated with WATBAL along with rainfall data during the season.*

Finally, the rooting profile of sorghum was simulated and outputs from the model for three different growth stages are presented in **Figure 6 A-D**. It is observed that when the soil horizon code (SCD in **Table 29**) in the model for the different layers is set to a no-stress value of 1.0, the root length densities are as in **Figure 6 A**. But by changing this code to a value nearer 0 (no root growth) with a trial-and-error exercise, the density curve becomes more exponential and closer to the observed data as in **Figure 6 D**.

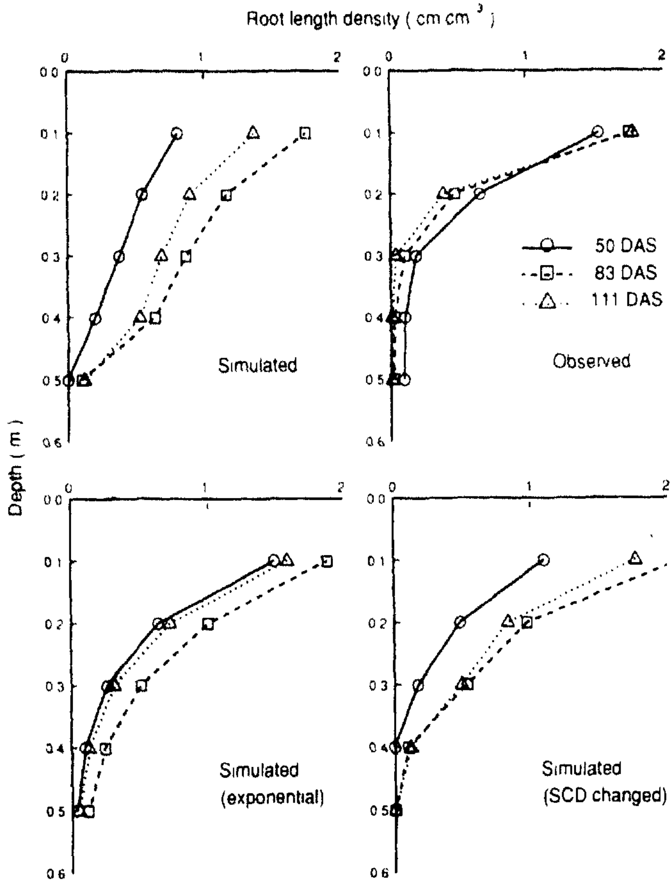


*Figure 6. Root length density of sorghum simulated with (A) SCD = 1 in all layers, (B) observed, (C) exponential simulation, and (D) SCD = 1 in top two layers and 0.3, 0.2, and 0.1 in the third, fourth, and fifth layers, respectively.*

This indicates that there must have been other factors involved in the model, which control the root proliferation much more strongly than bulk density and coarse fragment. It was observed that the thickness of plough layer in this experimental site was 20-30 cm in most places, below which a stony hard pan layer appeared. However, this visual observation is not reflected by the bulk density and coarse fragment measured (**Table 29**). Those two parameters show no clear changes at around 20-30 cm depth. In such circumstance, running the program with a different SCD is the only way to have a better agreement with real data.

Seasonal changes in root length density at different depths are presented in **Figure 7**. The simulation predicts that under the present experimental conditions roots hardly reach below 40 cm during vegetative growth and stop their extension at around 70 days after sowing, after which root length density gradually decreases in the upper layer.

**References**


**Jones, C.A., Bland, W.L., Ritchie, J.T.,** and **Williams, J.R.** 1991. Simulation of root growth. Pages 91-123 *in* Modeling plant and soil systems, Hanks, J. and Ritchie, J.T. (eds.). American Society of Agronomy, Inc., Crop Science Society of America, Inc., and Soil Science Society of America, Inc.

**Thornley, J.H.M.** 1977. Root:shoot interactions. Pages 367-389 *in* Integration of activity in the higher plant, Symposium XXXI, of the Society for Experimental Biology. UK: Cambridge Univ. Press.


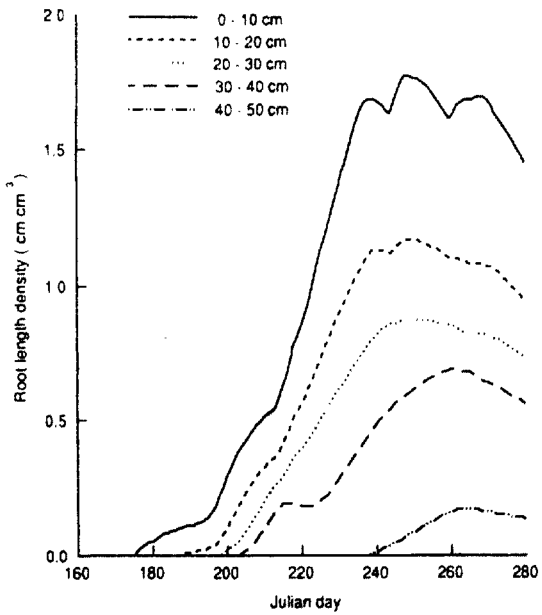


*Figure 7. Seasonal changes in root length density of sorghum at the upper five layers (10 cm interval) obtained by simulation.*

## Entomology

### LP-461(90)IC/IC: Integrated pest management of pigeonpea pests

**Scientists : TGS, CSP**

**Objective 1.** To understand the effect of manipulations of the cropping system on the interactions between host-plant, pests, and their natural enemies, as a means of minimizing pest infestations.

**Analysis** of data collected in the pigeonpea:cotton intercropping trial last season is continuing. *Helicoverpa* populations were compared under sprayed and nonsprayed conditions in different cropping systems. Preliminary results have been reported in earlier quarterly reports.

Attempts are being made to retrieve the past data on different host plants of *Helicoverpa* from the computer files of the Farm Development and Operations (FDO) Unit of ICRISAT to work out possible correlations between the trap catches and larval infestation on the crop. The data on larval activity during the past 4 years have been retrieved in the required form. The data on average monthly populations of *H. armigera* on ICRISAT crops, other crops in general, and the weed *Lagascea mollis* from June 1992 to February 1993 are given in **Table 30.**

Barring the attractive phases of the crop *H. armigera* activity on *L. mollis* is most interesting to note. The weed supports *H. armigera* throughout the year (data for March and May being collected) and plays a most important role in the carry over of the pest particularly during the beginning of the rainy season. The first step in the management of *H. armigera* should therefore be to check this weed which grows in abundance on field bunds, on road sides, and in fallow lands.

**Table 30. *Helicoverpa* populations (larvae per 100 plants) recorded in different months on crops - sorghum, pearl millet, groundnut, pigeonpea and chickpea, and other crops in general, and the weed *Lagascea mollis*, ICRISAT Center, 1992-93.**

| Months | Sorghum | Pearl millet | Ground-nut | Pigeon-pea | Chick-pea | Other[1] crops | *Lagascea mollis* |
|---|---|---|---|---|---|---|---|
| 1992 June | 0 | 0 | 1 | 1 | 0 | 0 | 7 |
| July | 0 | 0 | 3 | 8 | 14 | 1 | 36 |
| Aug | 15[2] | 15[2] | 6[2] | 5 | 20 | 5 | 31 |
| Sep | 121[2] | 24[2] | 4 | 38 | 21 | 10[1] | 52 |
| Oct | 2 | 17 | 4 | 105[2] | 39 | 8 | 62 |
| Nov | 19 | 11 | 0 | 164[2] | 198[2] | 31[2] | 60 |
| Dec | 53[2] | 5 | 2[2] | 166[2] | 139[2] | 32[2] | 86 |
| 1993 Jan | 27 | 1 | 1 | 182[2] | 218[2] | 3 | 48 |
| Feb | 5 | 1 | 2 | 46 | 242[2] | 1 | 21 |
| Sprays done (average) | <1 | <1 | 1-2 | 4-5 | 3-4 | 1 | 0 |

1. Maize, cotton, cowpea, soybean, sunflower, safflower etc. (small area)
2. Indicates most vulnerable periods of the major portion (80%) of the crop which is flowering + grain filing in almost all crops except chickpea which is vulnerable throughout its growth.

**Objective 2.** To develop sampling plans for *Helicoverpa armigera* on pigeonpea which will provide farmers with a simple technique for monitoring and decision making in pest management.

These data are also currently being analyzed. The analysis will describe *Helicoverpa* egg and larval distributions within and between pigeonpea plants. The data will then be used to develop sampling plans.

**Objective 3.** To develop and implement in collaboration with NARS, integrated pest management programs for pigeonpea pests in farmers' fields by incorporating resistant varieties, enhanced biological control, and manipulation of the farming system to minimize the pests' incidence.

During the 1992/93 season, on-farm trials were carried out in two villages in Maharashtra. These trials, in collaboration with the Zonal Coordination Unit for Transfer of Technology Projects (ICAR) and the Marathwada Agricultural University, included evaluating pest-tolerant germplasm and initial diagnostic surveys. They are the first step in the development and implementation of integrated pest management for pests of pigeonpea in cotton:pigeonpea intercrop systems. During this quarter, discussions were held with the farmers who had grown ICRISAT cultivars. The farmers evaluated the material using a technique known as 'matrix ranking'. This methodology has the advantage of rapidly providing a qualitative view of farmers' preferences. It has the additional advantage of minimizing some of the possible biases found in traditional interviewing techniques.

Farmers in the two villages, located in adjacent districts, had clearly different reactions to the ICRISAT genotypes. In one village there was a favorable response, with enthusiasm for growing the cultivars next year. In Daithna, the other village, farmers were not so satisfied with the performance of the ICRISAT material. The yield of ICRISAT cultivars was generally better than that of local cultivars and pod borer damage was less. Farmers in Daithna felt that the duration of ICRISAT material was too long. Several difficulties which were encountered in this first year make it difficult to draw broad conclusions from the data. One important factor however, is the need to select a cultivar with a duration matching the requirements of the farmers. We have made plans to continue this work and to include the application of NPV, a viral pathogen of *Helicoverpa*, next year.

**LCP-152(90)IC/IC: Studies on the host-selection behavior of *Helicoverpa armigera* with particular reference to pigeonpea and chickpea**

**Scientists: TGS**

During this quarter, a visiting Research Fellow from the University of the Philippines completed a series of experiments investigating the host selection and utilization behavior of *Helicoverpa* on pigeonpea. Ovipositional preferences were studied among six short-duration genotypes. Under both choice and no-choice conditions, females laid more eggs on ICPL 87 than on any other cultivar (**Table 31**). Interestingly, ovipositional preferences seemed to be related to flower color. It may be that this is a coincidence and is due to the choice of genotypes. This finding needs to be confirmed with a larger number of entries, however, it is an interesting result. Differences in larval preference were not significant, though ICPL 87 consistently attracted more larvae under choice feeding tests.

The effect of these different genotypes, and of specific plant parts, on *Helicoverpa* growth, development and survival was also studied. Larvae which fed on pods developed faster, grew larger, survived better and lived longer as adults compared to larvae which fed on flowers. Larvae which were fed only on leaves took the longest time to develop, had the lowest weight, the highest mortality, and the shortest adult lifespan. The differences between larvae which fed on pods and larvae which fed on leaves were as great as seven fold. Differences in growth, development, and survival between genotypes were not nearly as great as the differences due to the plant part consumed. Larval mass, and the survival rate of larvae and pupae were equivalent between genotypes. Larval and pupal development time, pupal mass, and adult

**Table 31. Oviposition of *Helicoverpa armigera* on six short-duration pigeonpea genotypes, ICRISAT Center, 1992.**

| Genotype | Flower color | Number of Eggs | |
|---|---|---|---|
| | | Choice Test | No-choice Test |
| ICPL 87101 | Purple | 5.1 | 53.0 |
| ICPL 86012 | Purple | 7.0 | 292.0 |
| ICPL 86005 | Purple | 8.9 | 87.0 |
| ICPL 86015 | Yellow | 12.3 | 140.0 |
| ICPL 88023 | Orange | 13.8 | 162.0 |
| ICPL 87 | Yellow | 29.2 | 502.0 |
| Grand mean | | 12.7 | 69.4 |
| LSD 0.05 | | 6.21 | 11.3 |
| CV (%) | | 47.5 | 27.1 |
| SE ± (m) | | 3.49 | 13.28 |

longevity varied between genotypes. There were also significant interactions between genotypes and plant parts, however, a pattern was evident. ICPL 87 and 88023 were relatively more conducive to *Helicoverpa* growth and development than the other genotypes. None of the genotypes showed strong, consistent antibiosis to *Helicoverpa*.

**LCP-153(90)IC/IC: Integrated pest management in chickpea**

No activity during this period.

**LCP-154(90)IC/IC:Identification and utilization of host-plant resistance to *Helicoverpa armigera* in pigeonpea and chickpea, and to *Melanagromyza obtusa* and *Maruca testulalis* in pigeonpea**

**Scientist: TGS**

**Objective 1.** Identify sources of resistance to key pests of pigeonpea and chickpea.

Pigeonpea germplasm of different duration groups was grown under nonsprayed conditions in the 1992/93 season and evaluated for resistance to pod borer (*Helicoverpa armigera*), podfly (*Melanagromyza obtusa*) and pod wasp (*Tanaostigmodes cajaninae*). Counts of *Helicoverpa* eggs and larvae were taken one or more times during the season in addition to routine pod scoring at harvest. The purpose of these pod borer counts is to ensure that lines which perform well are not "escaping" pest attack due to phenological differences.

**Extra-short duration**

Fifty-four $F_4$ selections from Hisar were evaluated in a replicated trial and compared to the controls Prabhat and Pant A1. Pod borer populations were high and ranged from 0 to 19 eggs and larvae from 0 to 6 $plant^{-1}$.

Pod damage due to pod borer was exceedingly high (+60% on all lines) and only seven selections had less damage than the controls. Pod borer was the largest contributor to total pod damage in this trial. Podfly damage was generally low, as expected from short-duration material, however 11 lines suffered more than 10% damage. Pod wasp damaged on a single line was at a very low level (<2%). The heavy pod borer incidence resulted in very low yields and only three lines produced more than 100 kg ha$^{-1}$. Though yields were low, all but seven of these lines produced more than one or both of the controls.

**Short duration**

Nine short-duration cultivars were compared with Pant A1 in a replicated trial. *Helicoverpa* populations ranged from 1 to 10 eggs and 0 to 2.5 larvae plant$^{-1}$. Pod borer damage was in excess of 65% and was statistically similar on all the cultivars. Podfly damage ranged from 7.4 to 16.3% and was lowest in the control. Damage by pod wasp was less than 1% in all cultivars. Yields were very low (<110 kg ha$^{-1}$) and only four cultivars yielded more than the control.

**Medium duration**

Seven medium-duration pigeonpea cultivars were compared with BDN 1 in a replicated trial under sprayed and nonsprayed conditions (**Table 32**). Egg counts of *Helicoverpa* varied from 5.4 to 12.8 per plant on nonsprayed treatments and 8.8 to 14.2 on sprayed treatments. Curiously, egg populations were always higher on sprayed treatments of the same cultivar. This has been observed in other trials, specifically the cotton:pigeonpea intercropping trial (see above and the Oct-Dec 1992 Quarterly Technical Report). Larval populations were between 0.9 and 2.6 larvae per plant on nonsprayed treatments and below 0.8 larvae plant$^{-1}$ on sprayed treatments. Pod damage was significantly reduced, roughly three times, for all cultivars when protected with insecticide sprays. Yields were very low in this trial, though sprayed treatments produced three times the yield of the nonsprayed treatments. The low yields were due to poor growth in addition to pest damage.

**Objective 4.** Multilocational testing of the resistant genotypes in different agroecological zones in the SAT in collaboration with NARS.

See objective 3 of LP-461(90)IC/IC.

**LG-751(90)IC/IC: Biological studies of groundnut foliar pests carried out to provide background information for IPM Program**

**Scientists: JAW, GVRR**

**Objective 1.** Surveys in support of IPM research projects.

No insect pest surveys were carried out during this quarter.

**Objective 2.** Determination of the relationships between insect density and crop loss and subsequent economic analysis.

Experiments are in progress with five different varieties (ICGV 86029, 86030, 86031, 86590, and ICG 221) using different larval densities of artificially reared *Spodoptera*, released at different stages of the crop.

**Table 32. Medium-duration pigeonpea cultivars grown under protected (5 sprays) and nonprotected conditions, ICRISAT Center, crop season 1992/93.**

| | *Helicoverpa armigera* pest counts[1] | | | | | | Pod damage (%) due to specific pests[2] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Eggs plant⁻¹ | | | Larvae plant⁻¹ | | | Pod borer | | | Podfly | | | Podwasp | | | Pod damage | | | Total yield (kg ha⁻¹) | | | |
| Cultivars | US | S | Mean | US | S | Mean | US | S | Mean | US | S | Mean | US | S | Mean | US | S | Mean | US | S | Mean | Days to 50% flower |
| ICP 1903-E1 | 7.7 | 8.9 | 8.3 | 1.2 | 0.2 | 0.8 | 61.7 | 12.0 | 36.9 | 3.8 | 2.7 | 3.3 | 0.2 | 0.0 | 0.1 | 66.1 | 14.7 | 40.4 | 233 | 627 | 430 | 130 |
| ICPL 84060 | 5.4 | 8.8 | 7.1 | 1.3 | 0.4 | 0.9 | 56.7 | 23.1 | 39.9 | 11.7 | 3.2 | 7.5 | 0.8 | 0.2 | 0.5 | 68.0 | 26.6 | 47.3 | 267 | 664 | 465 | 127 |
| ICPL 87089 | 6.6 | 9.2 | 7.9 | 0.9 | 0.4 | 0.7 | 59.9 | 21.4 | 40.7 | 8.7 | 2.5 | 5.6 | 0.7 | 0.0 | 0.4 | 68.2 | 24.9 | 46.6 | 157 | 721 | 439 | 130 |
| ICP 10531 | 10.4 | 10.6 | 10.5 | 1.2 | 0.5 | 0.8 | 54.2 | 12.4 | 33.3 | 8.5 | 2.5 | 5.5 | 0.3 | 0.0 | 0.2 | 61.8 | 15.3 | 38.5 | 239 | 663 | 451 | 133 |
| ICP 6840-1 | 11.9 | 12.8 | 12.3 | 1.7 | 0.6 | 1.1 | 62.1 | 11.8 | 37.0 | 3.9 | 1.7 | 2.8 | 0.1 | 0.0 | 0.1 | 66.4 | 13.7 | 40.0 | 245 | 753 | 499 | 130 |
| ICP 1811-E3 | 12.8 | 14.2 | 13.5 | 1.7 | 0.8 | 1.2 | 58.7 | 25.7 | 42.2 | 3.7 | 2.3 | 3.0 | 0.9 | 0.0 | 0.4 | 63.6 | 29.0 | 46.3 | 137 | 644 | 391 | 130 |
| ICP 10235-S4 | 9.4 | 11.4 | 10.4 | 1.5 | 0.4 | 1.0 | 70.0 | 12.2 | 41.1 | 3.1 | 2.1 | 2.6 | 0.2 | 0.0 | 0.1 | 73.5 | 14.6 | 44.0 | 276 | 1020 | 648 | 131 |
| BDN 1 (Control) | 8.5 | 12.7 | 10.6 | 2.6 | 0.8 | 1.7 | 100.0 | 29.1 | 64.5 | 0.0 | 2.8 | 1.4 | 0.0 | 0.4 | 0.2 | 100.0 | 33.4 | 66.7 | 16 | 564 | 290 | 124 |
| Mean | 9.1 | 11.1 | 10.1 | 1.5 | 0.5 | 1.0 | 65.4 | 18.5 | 41.9 | 5.4 | 2.5 | 4.0 | 0.4 | 0.1 | 0.3 | 70.9 | 21.5 | 46.2 | 196 | 707 | 452 | 129 |
| SE (Spray) | | | 0.76 | | | 0.07 | | | (1.34) | | | (0.18) | | | (0.33) | | | (1.28) | | | 31.7 | |
| SE (Cultivars) | | | 1.16 | | | 0.11 | | | (1.79) | | | (1.80) | | | (1.10) | | | (1.87) | | | 48.8 | |
| SE (Spray * Cultivars) | | | 1.71 | | | 0.17 | | | (2.73) | | | (2.39) | | | (1.49) | | | (2.79) | | | 71.9 | |
| CV (%) | | | 28.3 | | | 28.5 | | | (10.9) | | | (43.4) | | | (213.7) | | | (10.6) | | | 26.5 | |

1. *Helicoverpa* egg and larval number (mean of 8 observations (6 plants per replicate))
2. Percentage data transformed with arcsine $\sqrt{\%}$ before analysis, transformed values in parentheses.

**Objective 3.** Testing and installation of a network of pheromone traps for key groundnut pests to facilitate forecasting pest damage across the SAT.

Groundnut leaf miner and *Spodoptera* pheromone septa have been despatched to our collaborators to carry out monitoring exercise in their locations. During this period at IC detailed observations pertaining to groundnut leaf miner adult activity (monitored through pheromone traps) followed by oviposition and larval populations have been carried out. Detailed results will be furnished in the next report.

**LG-752(90)IC/IC: Research on host-plant resistance to insects in the genus *Arachis* in the context of IPM of all pest classes**

**Scientist: GVRR**

**Objective.** To screen and exploit host-plant resistance to insects in the genus *Arachis*.
During January at 30 days after emergence of the groundnut crop, several pest resistant lines have been screened by releasing artificially reared *Spodoptera* larvae under field conditions. When two larvae per plant were released in a replicated trial we observed a range of 22-50% defoliation in different lines. In the third week of January, when the thrips population was at its peak (13 thrips terminal$^{-1}$), we screened breeders' pest resistant progenies and other germplasm including AICORPO materials. All these materials need to be scored against jassid injury during the first fortnight of April thus the pest resistant material that is under test in the current season will have been screened for resistance to *Spodoptera*, thrips, and jassids.

**LG-753(90)IC/IC: Cultural control of groundnut pests including the influence of crop management on the efficiency of natural control processes**

**Scientists: JAW, GVRR**

In order to evaluate the role of bird predation for suppression of key pests such as *Helicoverpa* and *Spodoptera*, some simple trials have been conducted at ICRISAT Center by releasing known populations under different nets. When the *Helicoverpa* larvae were exposed to natural conditions, we recorded 97% mortality in 24 h which was mainly contributed by birds (egrets, drongoes, and some other unidentified sparrows). Similar experiments with *Spodoptera* indicated about 20% contribution through birds to population suppression in 48 h. The difference in bird predation in these two species could be mainly due to the feeding habit of the pest on the crop. This phenomenon could play a significant role in developing future IPM strategies for the management of the above two species.

The insect pest observations taken in groundnut trials with and without polythene mulch clearly showed the avoidance by thrips of the mulched area. The data in **Fig. 8** shows a high thrips population density of around 13 thrips terminal$^{-1}$ in the third week of January when the crop was young. The mulched area attracted only 2 thrips terminal$^{-1}$ which was far below the threshold level. The same trend continued up to the second week of February; later the plants in the mulched area started showing thrips injury which could be due to the deteriorating effect of mulch due to dust. When the dust was cleared in the second week of February, again there was a clear cut decline in thrips population in the mulched area. However, by the second week of March, there was no effect of mulch which could be due to the complete canopy closure (**Fig. 8**).

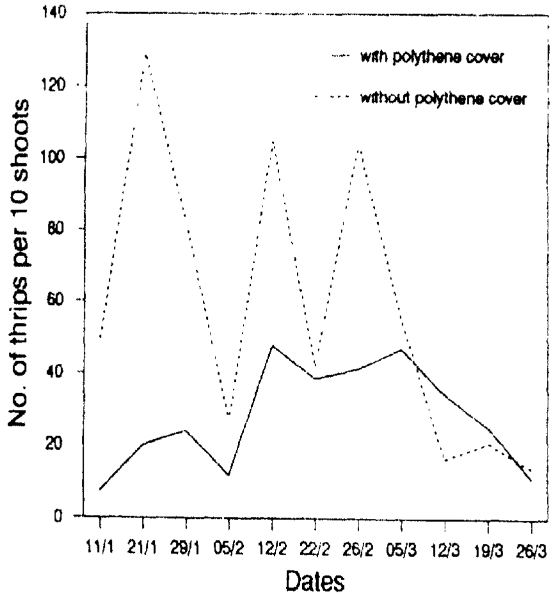


*Figure 8. Effect of polythene mulch on thrips population, ICRISAT Center, postrainy season 1992/93.*

**LG-754(90)IC/IC: The IPM of soil insects in groundnut fields**

**Scientists: JAW, GVRR**

Though we have not organized any separate experiments on soil insects during this season, we have noticed substantial termite activity in most of Alfisols (RP fields) on our farm. The breeders' drought trial in the southern side of RP 9B experienced up to 25% plant mortality caused by termites. Similarly, the trials in RL 19 on the eastern side had up to 10% plant mortality due to termites which necessitated the application of carbofuran.

**LG-756(90)IC/IC: Epidemiology and control of groundnut virus vectors in the context of integrated pest and disease management**

**Scientists: JAW, DVRR, KVL**

**Objective 1.** In association with the Legume Virology Unit to identify, characterize and describe the ecology of the vectors of groundnut virus diseases.

During this period studies on the effects of temperature on the developmental biology of *T. palmi* have been completed. These studies clearly showed that 25°C is the most suitable temperature to obtain high fecundity, adult emergence, and total larvae produced per female. Under laboratory conditions, 35°C was found to be unsuitable for rearing this species.

An evaluation of host suitability in laboratory conditions [comparing cowpea (*Vigna unguiculata*), urd bean (*Vigna mungo*), mung bean (*Vigna radiata*), soybean (*Glycine max*), groundnut, and sunn hemp (*Crotalaria juncea*)] revealed that mung bean is the most suitable followed by cowpea and urd bean. The number of larvae produced per female and percent adult emergence were significantly different on mung bean compared to groundnut. Detailed data will be reported in the next report after final compilation.

**LG-757(90)IC/IC: The rationalization of insecticide application for the control of groundnut pests within the context of IPM**

**Scientists: JAW, GVRR, NJA, CSP**

**Objective 1.** To develop insecticide regimes that are compatible with IPM schemes and that do not promote insecticide resistance.

During the 1992/93 postrainy season, insect pressure on the groundnut crop on the ICRISAT Center farm was not sufficiently serious to warrant significant insecticidal applications. In the third week of January thrips reached their peak infestation with 13 thrips terminal$^{-1}$ and later the population declined to 2 thrips terminal$^{-1}$ by the second week of March. In the third week of February there was only one groundnut leaf miner larva per 10 plants. By the third week of March, the population had increased 10 times, but was still much below the threshold level. Jassids started appearing on the crop in the third week of February at 1.3 jassids plant$^{-1}$ and later the population increased to 4.4 jassids plant$^{-1}$ by the 1st week of March. The population remained stable through March.

Observations on larval parasites of groundnut leaf miner during the first week of March indicated 28% parasitization and the parasite activity increased to 51% by the second week of March. Larval parasites of *Spodoptera* contributed up to 35% mortality during the first week of March.

**Insecticide resistance monitoring**

The pilot study on an insecticide resistance monitoring program covering ICRISAT Center, Ranga Reddy, Krishna, and Guntur Districts in Andhra Pradesh, has been completed for the 1992/93 cropping season. A formal report on the study to cover NRI/ICRISAT/IRAC interests in the work is being finalized. The monitoring protocols used in the study (explained in earlier quarterly reports) proved to be highly successful for monitoring insecticide resistance under Indian tropical conditions. The data are too extensive to present in this report, but, as an example, the data generated for seasonal changes in resistance to the pyrethroid and cypermethrin over the cropping season at ICRISAT Center and in the intensively-sprayed cotton-growing areas of Guntur District are shown in **Fig. 9**. Two cypermethrin discriminating doses (0.1 µg and 1.0 µg larva$^{-1}$) were used to monitor resistance, because the 0.1 µg dose, although being the true $LD_{90}$ for pyrethroid susceptible *H. armigera*, proved to be too low a dose for routine monitoring because of rapid saturation to 90-100% survival within a few weeks of the commencement of the cropping season. Cypermethrin 1.0 µg larva$^{-1}$ proved to be more useful, as this dose was sufficiently high to allow for further increases in insecticide resistance. The graphs clearly indicate that Guntur is experiencing a more severe pyrethroid resistance situation than is ICRISAT Center. This is not surprising as some farmers in the region applied up to 40 insecticidal sprays (average 25) to cotton during the season. However, the fact that *H. armigera* populations at ICRISAT also show high levels of resistance that increase over the cropping season, despite minimal use of pyrethroid insecticides on the farm, indicates that extensive migration of *H. armigera* moths from local and more distant sources is occurring in southern India.

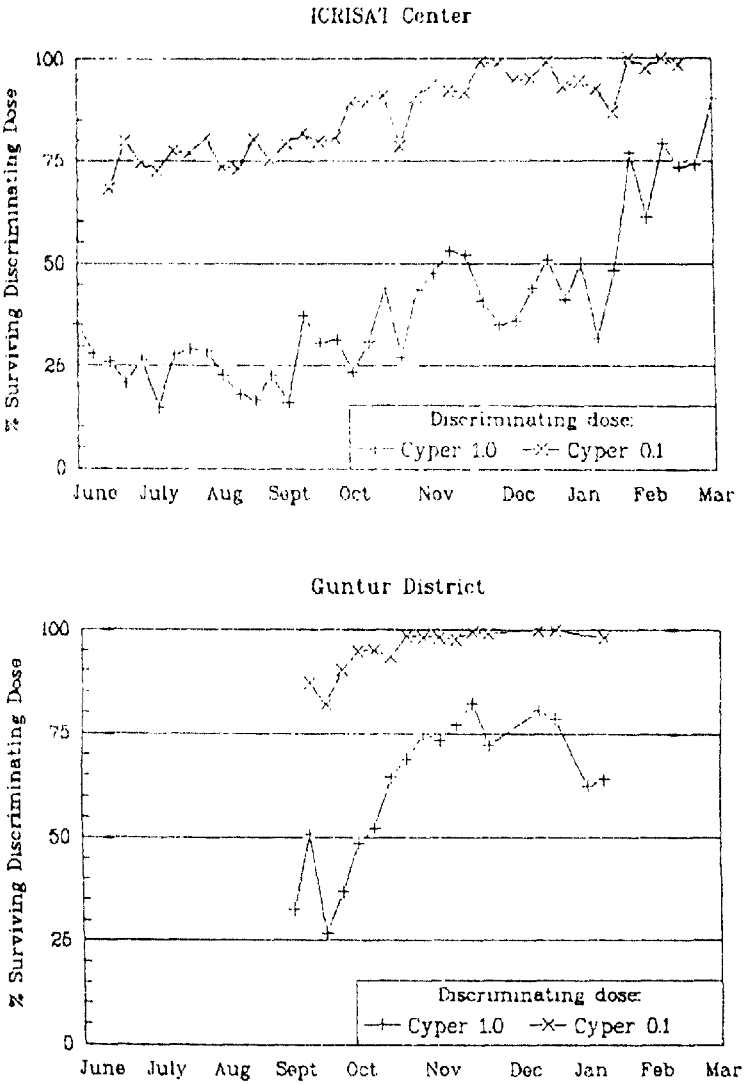


*Figure 9. Weekly measures of pyrethroid resistance in* Helicoverpa armigera *for ICRISAT Center and Guntur district during the 1992/93 cropping season. Results expressed as percentage of larvae (from field collected eggs) surviving the cypermethrin discriminating doses (0.1 and 1.0 µg per 30-40 mg larvae).*

In summary the results of the study demonstrated that southern India is facing a serious pyrethroid and endosulfan resistance problem. Limited monitoring with quinalphos indicated that organophosphate resistance also featured significantly. Resistance to pyrethroids and endosulfan increased markedly over the cropping season with the cumulative application of insecticides to field crops. Most farmers who were growing *H. armigera* susceptible crops complained of lack of efficacy of all available insecticides in controlling larvae. The resistance situation was worst in the intensively-sprayed cotton areas of Krishna and Guntur Districts. Assays with the synergist, piperonyl butoxide (Pbo) in combination with a pyrethroid showed that suppression of resistance by Pbo was limited, indicating that metabolic detoxification may not be the major resistance mechanism and nerve insensitivity and penetration resistance probably feature significantly in southern Indian *H. armigera* populations.

### Pyrethroid insecticide resistance mechanisms

Mr A West, Reading University, UK, spent 3 months with the NRI/ICRISAT project to investigate insecticide resistance mechanisms in *H. armigera*.

Resistance to the synthetic pyrethroids can be broadly grouped into three categories:

i. increased metabolic activity
ii. reduced or delayed penetration
iii. decrease in sensitivity of target site (nerve insensitivity)

In order to develop a practical insecticide resistance management program, it is essential to identify the relative frequency and importance of each of these mechanisms in field populations.

The most critical mechanism and the one which is most difficult to control is that of nerve insensitivity. To monitor this mechanism, staff at the Reading University have developed a laboratory-based cumulative assay capable of screening large numbers of insects for nerve insensitivity. Further improvements to the equipment, through a collaborative project with NRI, led to the design and construction of a portable kit suitable for field use in India. This was evaluated at ICRISAT Center.

*Heliothis armigera* from ICRISAT Center and Guntur Districts were assayed regularly between Nov 1992 and Jan 1993. Larvae from Guntur District typically showed the highest levels of resistance and demonstrated a high incidence of nerve insensitivity which did not change appreciably over the duration of the tests. The profiles recorded for ICRISAT populations originally showed low levels of nerve insensitivity, but later assays showed that the level increased significantly over the cropping season. We would tentatively suggest that this increase was due to pyrethroid spraying which had just begun at ICRISAT Center.

### Conclusions

1. All three mechanisms of insecticide resistance are present in the *H. armigera* populations assayed.
2. Nerve insensitivity, although present, is still relatively subordinate to penetration and metabolic resistance, but the use of pyrethroid insecticides appears to enhance selection towards nerve insensitivity.
3. There is some evidence of a fitness deficit associated with nerve insensitivity.
4. Sub-lethal applications of insecticide cause a relative increase in the frequency of nerve insensitivity within the surviving generation.

### Insecticide resistance in *Heliothis peltigera*

Large populations of *H. peltigera* were found on safflower (*Carthamus tinctorius*) on the ICRISAT farm during November 1992. The opportunity was taken to assay insecticide resistance in this species using a standard log-dose probit method.

*Heliothis peltigera* appeared to be fully susceptible to all the insecticide groups assayed (**Table 33**). There was no evidence for resistance to pyrethroids as the log-dose probit line produced a steep slope indicating homogeneity and no further suppression of resistance could be achieved through the addition of the synergist piperonyl butoxide (Pbo). The $LD_{50}$ for endosulfan at 3.59 µg $larva^{-1}$ was higher than expected, but the probit line slope of 3.2 indicated that the strain was probably homogeneous with respect to endosulfan susceptibility. Quinalphos produced a low $LD_{50}$ and very steep probit line slope indicating full susceptibility to organophosphate insecticides.

The finding that *H. peltigera* populations at ICRISAT Center are fully susceptible to insecticides is significant. Unlike *H. armigera* which has a wide host range and favors intensive agroecosystems, *H. peltigera* has been reported only from seven host plants, with the only commercial host being safflower. Safflower only is present in the cropping cycle from November to February (at a stage suitable for *Heliothis* development), and so for most of the year, it survives on wild hosts. As safflower is infrequently sprayed with insecticides, it is probably not surprising therefore that this species has not (yet) developed resistance to insecticides.

Disease-free cultures of several strains of *H. armigera*, *H. peltigera*, and *H. assulta* are being maintained in the Legumes Entomology Unit's insectary using new techniques developed under the NRI/ICRISAT collaborative project. Cultures have been supplied for use of the Legumes Entomology Unit's staff and the following institutions:

APAU, Lam, Guntur
CICR, Nagpur
IARI, New Delhi
NRI, UK
Osmania University, Hyderabad
Reading University, UK

**Objective 2.** The rationalization of insecticide use against legume pests.

During 1992/93, seven insecticidal treatments — acephate, quinalphos AF, quinalphos AF + cypermethrin, quinalphos EC, cypermethrin, methomyl, and endosulfan were evaluated for the control of *H. armigera* on chickpea along with a nontreated control. The results of this trial involving three replicate plots each measuring 33 x 14 m, are given in **Table 34**.

In relation to pretreatment observations, *H. armigera* activity in the treated plots decreased the most with acephate and the least with endosulfan. Surprisingly, *H. armigera* activity also decreased substantially (19%) in the control plots indicating a distinct role of natural control of *H. armigera* on chickpea. A closer look at the data on eggs on different size larvae indicated that there was much natural reduction in eggs and small larval populations in control plots.

**Table 33. Toxicity of topically applied pyrethroid, cyclodiene, and organophosphate insecticides to 30-40 mg *H. peltigera* larvae collected from ICRISAT Center.**

| Insecticide | n | LD50 | LD90 | Slope (S.E.) |
|---|---|---|---|---|
| Cypermethrin | 229 | 0.006 | 0.014 | 3.77 (0.42) |
| Cypermethrin + Pbo | 335 | 0.007 | 0.034 | 1.81 (0.19) |
| Endosulfan | 246 | 3.59 | 9.02 | 3.20 (0.34) |
| Quinalphos | 235 | 0.035 | 0.065 | 4.89 (0.70) |
| Monocrotophos | 228 | 0.538 | 2.89 | 1.75 (0.26) |

**Table 34. Average *Helicoverpa* activity during the 14-day period after insecticide applications on chickpea, ICRISAT Center, postrainy 1992-93.**

| | | | *Helicoverpa* larvae plant[1] | | | | |
|---|---|---|---|---|---|---|---|
| | | | Days after application | | | | |
| Insecticide | Dose ha[1] | Before | 2 | 5 | 7 | 14 | Average |
| Acephate 75 SP | 1 0 kg | 8 40 | 1 96 | 0 81 | 0.71 | 0.76 | 1.06(12 3)[1] |
| Quinalphos 20 AF | 2.0 kg | 8.68 | 2.69 | 1 85 | 1 59 | 1.94 | 2.01(23.2) |
| Quinalphos 20 AF + Cypermethrin 10 EC (5 . 1) | 2.0 L | 8 60 | 2.80 | 2.98 | 2 39 | 2 18 | 2.59(30 1) |
| Quinalphos 25 EC | 2.0 L | 7.30 | 2.39 | 2.52 | 2 80 | 2.32 | 2 51(34 4) |
| Cypermethrin 10 EC | 1 0 L | 9 06 | 3.31 | 2 89 | 2.83 | 2.22 | 2.81(31.0) |
| Methomyl 24 EC | 2.0 L | 6.77 | 2.25 | 1 99 | 2 27 | 2.87 | 2.34(34.5) |
| Endosulfan 35 EC | 2.0 L | 6 16 | 3.11 | 3.07 | 2.64 | 2.71 | 2.88(46.7) |
| nontreated control | | 6.68 | 5.98 | 5.87 | 5.42 | 4.36 | 5.41(81.0) |
| SEm | | ±0.63 | ±0 73 | ±0 84 | ±0 78 | ±0.56 | ±0.71(11.9) |

1. Values in parentheses indicate percent activity during the 14-day period in relation to pretreatment activity

## Pathology

**LC-228(90)IC/IC: Biology and management of wilt and root rots of chickpea**

**Scientist: MPH**

**Field screening**

Observations on the incidence of wilt and dry root rot in international nurseries, new and advanced germplasm lines, AVT's and breeding material were completed in February. The promising lines/plants thus selected were harvested in March from wilt-sick plots and multiple disease sick plot. The data are being processed. Mortality due to fusarium wilt was dominant followed by mortality due to dry root rot.

**Biological control of soilborne pathogen**

**Screening of antagonists**

**In vitro**

**Fungi**

Fungi were screened in vitro for their ability to inhibit the germination, and to parasitize the sclerotia of *S. rolfsii*. One mL spore suspension ($10^6$ $mL^{-1}$) of the test fungi were poured onto 1% water agar plate and spread evenly. About 300 sclerotia of *S. rolfsii* obtained from 20-day-old groundnut shell culture were placed on such plates and incubated at 25±1°C. A water agar plate drenched with sterile distilled water served as a control. After 3 days, observation on the number of sclerotia germinated, and the number of sclerotia parasitized were recorded. Fungi were grouped according to their ability to inhibit the germination, and to parasitize the sclerotia. Four isolates of *Trichoderma* (34, 38, 41, and NP-1) were selected for further studies.

**Bacteria**

The ability of bacterial isolates to inhibit the mycelial growth of *S. rolfsii* was recorded on PDA. PDA plates were inoculated at the periphery with one loopful of bacterial suspension (24 h old culture) at four points. The plates were centrally inoculated with 8 mm mycelial disc of the test pathogen and incubated at 25±1°C until the control plates were fully covered with *S. rolfsii* growth. The area covered by *S. rolfsii* in control plate and in plates inoculated with bacterial cultures was measured and percent inhibition calculated. The isolates were grouped according to their ability to inhibit the mycelial growth. The isolates showing more than 30% inhibition (isolate nos 32, 37, 40, 43, 44, 45, and 48, all fluorescent pseudomonads) were selected for further studies.

**Pot experiments**

The selected fungal and bacterial isolates were evaluated for their ability to reduce mortality of chickpea in *S. rolfsii* sick soil using Annigeri as the test variety. Seeds were coated with $10^7$ conidia of *Trichoderma* $m^{-1}$ and $10^9$ cells of fluorescent pseudomonads. *Trichoderma* isolates were grown on PDA plates for 7 days, spores harvested with a camel hair brush, seeds dipped in the suspension for 2 h, and dried overnight. Fluorescent pseudomonads were grown on King's B medium for 2 days and seeds coated as described above. Treated seeds were sown in *S. rolfsii* sick soil in 0.5 kg capacity plastic pots (5 seeds were sown in each pot) and kept in a greenhouse at 25°C. Observations on germination was taken at 10 days, and final stand counts at 30 days after sowing. One isolate of *Trichoderma* (NP-1) was effective in reducing the mortality of chickpea by *S. rolfsii*.

**Biological control of *Rhizoctonia bataticola***

**Screening of antagonists**

**In vitro**

**Fungi**

Fungi were screened for in vitro antagonism using the dual culture technique. *Rhizoctonia bataticola* was co-inoculated with the test antagonists at a distance of 4 cm on PDA plates. Observations were recorded on the time taken by each isolate to completely overgrow the pathogen colony and the isolates were grouped accordingly. Based on these observations, isolates 27 (*Trichoderma*), 78, and Ant 2 (both *Penicillium*) were selected for further studies. Another isolate 67 (*Aspergillus*) exhibited strong antibiosis against *R. bataticola* in dual culture and this isolate also was included in further studies.

**Bacteria**

The bacteria were screened as described for *S. rolfsii*. The bacteria were grouped according to their ability to inhibit the mycelial growth of *R. bataticola*. The two isolates (12 and 32, both fluorescent pseudomonads) were selected for further studies.

**Blotter test**

The selected fungal and bacterial isolates were further screened by using the blotter test developed for laboratory screening for dry root rot resistance, using the susceptible control BG 212 as the test variety. The fungi were grown in potato dextrose broth (100 mL in 250 mL flask) for 7 days. The fungal mat from each flask was added to 100 mL water and churned for 2 min. Roots of chickpea were placed in this suspension for about 5 min, then put in a moist blotter and incubated at 35°C for 10 days with regular watering. The antagonists were applied to roots either 1 day before or 1 day after dipping in *R. bataticola* suspension, or simultaneously. The extent of root discoloration was scored using a 1-9 point scale. Results indicate a negative effect of antagonist application on the disease severity. Isolates 27, 67, and Ant 2 significantly reduced the disease. The response was better when the antagonists were applied one day before the pathogen inoculation.

The bacterial antagonists were multiplied in King's B medium for 2 days in a shaker. The effect of bacterial suspension ($10^{-8}$ mL) on dry root rot in the blotter was tested as described for fungal antagonists. However, the roots putrified probably due to high temperature and high moisture.

**Effect of source of PDA on antibiosis by isolate 67 (*Aspergillus*) against *R. bataticola***

The isolate 67 (*Aspergillus*) produced a perfect stage (cleistothecia) when cultured on PDA prepared from potato, dextrose and agar in the laboratory. But, it produced only the imperfect stage (conidial stage) when cultured on HiMedia brand ready-made PDA under the same conditions of incubation (25±1°C, 12 h dark and 12 h light). When co-inoculated (dual culture), only the conidial state, not the perfect state exhibited antibiosis — a phenomenon that deserves investigation in detail.

**LC-229(90)IC/IC: Biology and management of foliar diseases of chickpea**

**Scientist: MPH**

**Field screening**

Observations were recorded in the ascochyta blight nursery at Hisar and the botrytis gray mold nursery at Pantnagar in February. Final observations will be recorded in early April.

**Plant Growth Room Screening**

Entries from the chickpea international nurseries, coordinated varietal trials, and lines received from other locations in India were screened in the controlled environment for their reactions to botrytis gray mold and ascochyta blight.

### *Biological control of Botrytis cinerea*

#### *Screening of antagonists*

##### *In vitro*

Fungi isolated from the chickpea rhizosphere were co-inoculated with *Botrytis cinerea* on PDA plates and incubated at 25±1°C. The isolates were grouped according to the time taken to completely overgrow the test pathogen. The result suggests that the isolates 1, 15, 23, 26, and 29 (all *Trichoderma*) were most effective in overgrowing the *Botrytis* colonies in dual culture. These five isolates were further screened in the growth room for their ability to suppress gray mold.

#### Screening in the growth room

For screening of antagonists and for other experiments in the growth room, the technique developed for screening for resistance to *Botrytis* gray mold was followed. Variety H-208 (susceptible control) was used throughout the investigation. Seedlings were raised in plastic trays (38 x 27 x 7 cm) containing sand:vermiculite (4:1) for 10 days in a greenhouse. Trays were shifted to a growth room before spraying with the pathogen, antagonist or fungicide. The temperature was maintained at 24±2°C. Relative humidity was maintained at 95-100% for the first 5 days, and for the next 5-6 days leaf wetness was maintained by intermittent spraying with water from a knapsack sprayer. For preparation of inoculum *B. cinerea* was multiplied on potato dextrose broth for 10 days at 25±1°C. The fungal mat was harvested and macerated in a blender for 2 min, sieved through two layers of muslin cloth, and the spore concentration adjusted to 3 x $10^5$ $mL^{-1}$. The suspension also contained mycelial fragments. The suspension with mycelial fragments and conidia was sprayed on the seedlings until run-off (approximately 50 mL $tray^{-1}$) and then allowed to dry for 2-3 h before putting-on the humidifiers. The disease symptoms started appearing after 48 h, and after 72 h, 50-60% disease could be observed. Disease severity was scored on a 1-9 scale.

The selected isolates (*Trichoderma* 1, 15, 23, 26, and 39) were multiplied on PDA plates for 7 days. The spores were harvested using a camel hair brush and their concentration in water was adjusted to $10^8$ conidia $mL^{-1}$. The spore suspension was sprayed on seedlings 1 day before *Botrytis*. The disease rating was recorded 10 days after the *Botrytis* spray. Seedlings sprayed only with *Botrytis* served as control. The results indicate that among the five isolates tested, *Trichoderma* 15 was the most effective in reducing the gray mold severity, and hence, this isolate (designated as T-15) was used for further studies.

#### Biological control

*Trichoderma* 15 was evaluated at two spore concentrations ($10^7$ and $10^8$ spores $mL^{-1}$, harvested from PDA plates) with or without carboxy methyl cellulose (CMC, 0.5% water suspension). In another treatment, *Trichoderma* was multiplied on PD broth for 7 days, macerated, and the spore concentration adjusted to $10^7$ $mL^{-1}$ (the suspension also contained mycelial fragments). This was also applied alone or with CMC. *Trichoderma* was applied to seedlings 1 day before the *Botrytis* spray and observations recorded from 3rd day onward, every alternate day. The results indicate that *Trichoderma* suspension from broth culture ($10^7$ conidia $mL^{-1}$ along with mycelial fragments) applied with 0.5% CMC gave maximum control. In subsequent experiments, this combination was used as a standard method of *Trichoderma* application.

LP-502(90)IC/IC: Management of phytophthora and alternaria blights and other stem and leaf diseases of pigeonpea

Scientist: MVR

**Powdery mildew resistance in African pigeonpea germplasm**

Powdery mildew of pigeonpea caused by *Oidiopsis taunca* (Lev.) Salmon (*Leveillula taurica* [Lev.] Arnaud), though widespread in most of the pigeonpea growing countries of the Indian subcontinent and eastern Africa, is at present a minor disease. The disease mostly occurs on the older leaves. It only becomes evident late in the season when the crop news maturity and therefore does not cause much yield loss. But occasionally the disease can cause severe defoliation affecting both pod-setting and pod-filling. At IC the disease may become severe in the December-January period when the crop is ready for harvest. Experience with multilocational trials in Kenya and Malawi has shown that germplasm lines from India and breeding materials developed at IC, suffer much more from powdery mildew than do African landraces. Complete defoliation of the exotic materials with significant loss in yield was often caused by powdery mildew when hardly any disease was present on the local landraces. Observations in the germplasm evaluation block at IC also indicated the resistance of African pigeonpea landraces to powdery mildew. Kenyan landraces such as ICP 9150, ICP 13107, ICP 13156, and ICP 13232 remained almost free from disease when Indian landraces such as ICP 9850, BDN 1, C 11, and ICP 8863 showed nearly 100% defoliation. These observations point to the African pigeonpea germplasm as a likely source of resistance to powdery mildew. The African germplasm lines are usually of long duration with large, thick, and dark green or pigmented leaves. Their resistance merits investigation.

LP-503(90)IC/IC: Epidemiology and integrated management of pigeonpea wilt and sterility mosaic

Scientist: MVR

**Population dynamics of the vector of sterility mosaic *Aceria cajani***

The incidence of sterility mosaic in pigeonpea fluctuates between the seasons and locations. The reasons for this are not well understood. The off-season sources of the pathogen and vector and climatic factors such as rainfall and temperature are suspected to influence sterility mosaic incidence. An experiment was initiated at IC in the rainy season of 1992 to study the influence of climatic factors such as rainfall, temperature, and relative humidity on *Aceria cajani* multiplication. The mite population was monitored on an sterility mosaic susceptible pigeonpea cultivar ICP 8863 throughout the crop season and in the off-season. The mite population was found to be positively correlated with minimum relative humidity and rainfall (**Table 35**). Mite multiplication was drastically reduced when minimum relative humidity decreased below 50%. This information is based on a single season's data and needs confirmation.

**Relationship between seasonal rainfall and onset of pigeonpea wilt**

Relationship between fusarium wilt (*Fusarium udum*) incidence in a wilt susceptible pigeonpea cultivar ICP 2376 in a Vertisol wilt-sick plot at ICRISAT Center, and seasonal rainfall and temperature was studied during the 1989, 1990, 1991, and 1992 rainy seasons. Wilt incidence was recorded at monthly intervals from sowing (June) to harvest (November). The rainfall data recorded in a meteorological observatory situated about 500 m away from the experimental plot and soil temperature recorded in the experimental plot itself were used for studying the relationship between wilt incidence and these two parameters. Wilt initiation was observed at the end of July in 1991, at the end of August in 1989 and 1992 and at the end of September in 1990, indicating lack of relationship between the age of the plant and wilt susceptibility. However, in all the four seasons, onset of wilt coincided with decrease in the rainfall (**Fig. 10**), indicating a negative relationship between these two parameters. No relationship of soil temperature with wilt incidence was observed. It appears that susceptibility of pigeonpea to fusarium wilt increases with increased moisture stress in soil resulting from decreased rainfall.

**Table 35. Correlation matrix of *Aceria cajani* population and climatic factors, ICRISAT Center, 1992/93.**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Mite population | 1 | 1.0000 | | | | | |
| Maximum temperature | 2 | -0.3466 | 1.0000 | | | | |
| Minimum temperature | 3 | 0.3486 | 0.4096 | 1.0000 | | | |
| Maximum relative humidity | 4 | 0.4436 | -0.8652 | 0.2570 | 1.0000 | | |
| Minimum relative humidity | 5 | 0.6100 | -0.3830 | 0.6659 | 0.8387 | 1.0000 | |
| Rainfall | 6 | 0.6823 | -0.1523 | 0.5028 | 0.4449 | 0.6786 | 1.0000 |
| | | 1 | 2 | 3 | 4 | 5 | 6 |

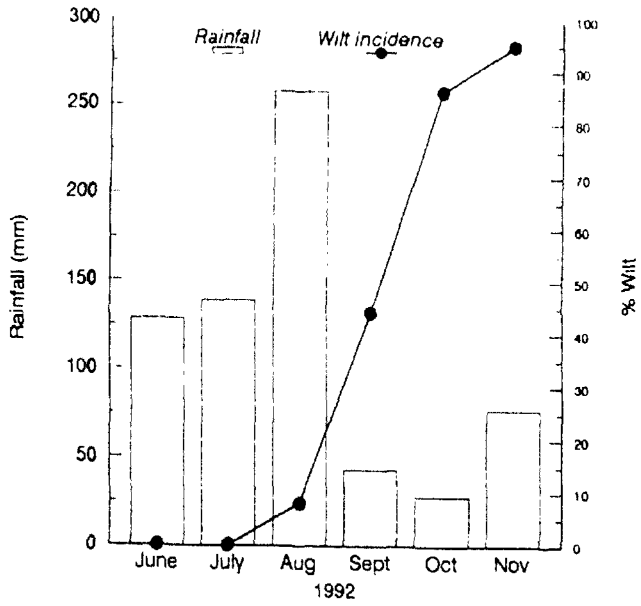


*Figure 10. Relationship between seasonal rainfall and wilt incidence in pigeonpea.*

**LG-801(90)IC/IC: Identification of stable resistance in groundnut to rust and late leaf spot**

**Scientist: VKM**

We studied components of resistance in 12 genotypes resistant to rust, together with two susceptible cultivars (TMV 2 and JL 24), using the detached leaf technique. Leaves from greenhouse-grown 40-days-old plants were inoculated with a urediniospore suspension (50 000 urediniospores $mL^{-1}$), and incubated at 25°C with 12 h photoperiod in Percival incubators. In the resulting single cycle of infection, measurements were made of several components of resistance infection frequency (IF), lesion diameter (LD), % leaf area damage (LAD), incubation period (IP - time taken for the appearance of 50% of the total pustules), and sporulation index (SI).

There were significant differences among genotypes for each component. All resistant genotypes had significantly lower LAD and LD than the susceptible controls cultivars TMV 2 and JL 24. All genotypes tested except ICG 10035 showed significantly higher IP than the susceptible controls cultivars ICG 10037, ICG 10049, ICG 10056, and ICG 10060 showed higher IP (17-19 days) than other genotypes. The genotypes ICG 10049 and ICG 10056 had low LD, LAD, and SI and high IP (17-18 days). Two genotypes (ICG 10058 and ICG 7898) had the lowest SI (2 on a 1-5 scale). The genotypes ICG 10023 and ICG 10029 exhibited high SI (4.5-4.7) comparable to the susceptible cultivars (4.8-5.0). These differences indicate the possibility of enhancing resistance to rust by combining resistance traits from the different genotypes.

In cooperation with breeders, we studied inheritance of components of rust resistance in progenies of two crosses (ICGV 88246 x PI 393516 and ICGV 88243 x PI 476183) using the detached leaf technique. Leaves from 40-day-old field-grown plants (200 for each cross) were used. Two leaves (fully expanded 2nd and 3rd leaves from the top) were collected, washed in running tap water, and incubated at 25°C for 24 h in a growth chamber with 12 h photoperiod. They were then inoculated with urediniospore inoculum, and incubated in the growth chamber. Measurements were made of several components of resistance (infection frequency (IF), lesion diameter (LD), % leaf area damage (LAD), incubation period (IP), and sporulation index (SI). LD, LAD, SI were measured 30 days after inoculations There are marked differences among populations of the crosses for different components. The data will now be analysed.

In another experiment, we are studying inheritance of components of rust resistance in the crosses involving TMV 2 and 83/151-3, using the 40-day-old plants grown in a greenhouse. In this study, 32 F1 plants derived from the cross TMV2 x 83/151-3, 41 plants from the reciprocal of the same cross 83/151-3 x TMV2 (RF1), 73 BC-2 plants (TMV2 x 83/151-3) x 83/151-3, 86 BC-1 plants (TMV2 x 83/151-3) x TMV2 (BC1), and 240 $F_2$ plants from TMV 2 x 83/151-3 ($F_2$) are being used. Thirty plants for each parent are also screened. After inoculation, the plants were incubated at 25°C in dew chambers without light for 24 h, then the inoculated plants were transferred to the greenhouse. The temperature and relative humidity were maintained at 25°C and 85%, respectively, in the greenhouse. The experiment will be concluded in the first week of April.

The International groundnut rust and late leaf spot disease nurseries sown at Bapatla, Andhra Pradesh State were evaluated for rust and late leaf spot when the plants were close to maturity. Rust severity was slightly less than late leaf spot severity. Rust scores ranged from 2 to 6 (6 in case of susceptible controls) and late leaf spot scores from 2 to 7 (7 for susceptible control).

**LG-806(90)IC/IC: Integrated management systems for control of aflatoxin contamination in groundnut**

**Scientist: VKM**

Messers Agrotech Projects, Madras, were advised on how to develop laboratory facilities and methodologies for aflatoxin detection and estimation.

Seed of three late leaf spot susceptible groundnut genotypes were supplied to the Nordic Gene Bank, Sweden.

**LG-809(92)IC/IC: Integrated management of groundnut diseases**

**Scientist: SP**

***Standardization of a Greenhouse Screening Technique for Resistance to Stem Rot***

*We conducted a series of experiments to develop a rapid, repeatable, and inexpensive procedure to screen groundnuts for resistance to stem rot (Sclerotium rolfsii) in the greenhouse. Objectives of these experiments were:*

1. *to identify the most suitable medium for mass multiplication of inoculum propagules (mycelial and sclerotial bodies),*
2. *to determine the effectiveness of inoculum propagules in infection and disease development,*
3. *to identify suitable organic matter for multiplication of the pathogen on the inoculated soil surface,*
4. *to determine the role in disease inducement of inoculum propagules placed at different depths in the soil and at different distances from the host on the soil surface,*
5. *to determine the inoculum potential required for disease development,*
6. *to identify the most suitable growth stage of groundnut for disease resistance screening, and*
7. *to standardize environmental conditions for disease development.*

The most effective medium for production of inoculum was autoclaved sorghum grain mycelial propagules were better than sclerotia for causing infection. Addition of organic matter to the potting soil improved disease establishment. Inoculum applied to the soil surface was effective.

Tests to date indicate that greenhouse temperatures between 15 and 35oC may be used for screening trials but best results were obtained at 25-35oC. Further experiments are in progress.

**R-360(90)IC/IC: Effects of weather on foliar diseases of groundnut and sorghum grain mold**

**Scientist: DRB, SP**

No progress during the quarter.

**LL-925(92)IC/IC: Management of important nematode pests of chickpea, groundnut, and pigeonpea**

**Scientist: SBS**

**Host-plant Resistance**

**Pigeonpea**. About 300 pigeonpea germplasm accessions were evaluated for resistance to the cyst nematode, *Heterodera cajani*. All the accessions except ICPs 1908, 2073, and 2083 were susceptible. The latter three genotypes had very few nematode females on roots and were selected for further evaluation. Accessions with resistance to *Rotylenchulus reniformis* were not found in the tested 300 germplasm lines. Promising accessions of *Cajanus platycarpa* are being evaluated for resistance to *Meloidogyne spp.*

**Chickpea**. Germplasm and breeding lines were evaluated for resistance to *Meloidogyne javanica* and *M. incognita* in infested soil in a farmer's field. All the breeding lines were susceptible. N 31, N 59, ICCC 42 and ICCV 90043 performed better than other genotypes. The nematode-infested soil was collected in large quantities to increase the nematode population and to ultimately develop a root-knot nematode sick plot.

**Groundnut.** Data on gall index, gall size, egg sac index, and plant biomass of 28 promising genotypes were statistically analysed to identify genotypes tolerant to *M. javanica*. The root-knot nematode populations (mixture of *M. incognita* + *M. javanica*), which were highly pathogenic to chickpea, did not infect groundnut genotypes ICGS 799, 7827, ICGVs 86600, 86635, 86644, 86707, 87288, UF 7153, and VRR 245. Groundnut is susceptible only to specific populations of *M. javanica*. In a greenhouse experiment, 94 selected germplasm lines are being screened for resistance to *M. javanica* (groundnut race?).

Plant parasitic nematodes in soil and root samples collected from the pigeonpea-growing regions of Uttar Pradesh State, India were identified to generic level and to species level in some cases. *Tylenchorhynchus vulgaris* and *T. mashhoodi* and *Helicotylenchus indicus* are the nematodes most commonly associated with pigeonpea. *H. cajani, R. reniformis* are more widespread than *Meloidogyne* spp. Data on population densities of major plant-parasitic nematodes in different districts and cropping systems will be analysed to identify the most important nematode species.

### Cropping Systems

Soil samples were collected in the 1992/93 postrainy season at crop harvest from fields BW 1, BW 2, BW 3B, BW 4C, and BW 5 at IC. Processing of soil samples and recording of data on densities of plant-parasitic nematodes is in progress. Population densities of *R. reniformis* in some sunflower and sorghum/pigeonpea plots ranged between 3500 and 7200 nematodes 100 $cm^{-3}$ soil.

### Diseases Ecology

Life table of *H. cajani* was developed on pigeonpea under controlled environmental conditions. The mortality rate was high during egg and juvenile stages before penetration of roots by the nematode. Females produced eggs between 23 and 31 days after juvenile penetration in the root. The mean generation time was 26.9 days and the net reproductive rate was 15.5. The true intrinsic rate was 0.102. The finite rate of natural increase indicated that *H. cajani* population will multiply 1.107 times a day and the nematode population would double in about 7 days.

### Biocontrol

Pathogenicity tests of two isolates of *Fusarium solani* (?) on *H. cajani* are in progress. The fungi were grown for 2 weeks on sand/sorghum bran medium in 250 mL flasks and 100, 50, 25 and 10 g medium was mixed with soil in the pots. Pigeonpea cultivar ICPL 87 was sown in these pots. One week old seedlings were inoculated with *H. cajani* juveniles and observations on nematode development, multiplication, and plant growth were recorded 40 days after inoculation. Fewer females (cysts) were produced on pigeonpea roots in pots containing 100 and 50 g of the colonized sand bran medium. Plant growth was better in fungus inoculated pots than in the control.

## Virology

**LC-230(90)IC/IC: Identification and characterization of economically important chickpea viruses and their management**

**Scientists: DVRR, RAN, MPH**

**Survey**. Chickpea plants showing "stunt-like" symptoms were collected from four different locations in India. They were brought to IC and tested by ELISA using the antiserum produced against chickpea chlorotic dwarf (CCDV) geminivirus and "chickpea luteovirus" (CPLV). Results showed that CPLV was predominant at IC (56.2%) and Junagadh (60.2%), and CCDV at Kargone, Madhya Pradesh (43.9%) and Hisar (Haryana) (96.7%). Although the majority of CPLV-infected plants from these locations showed weak reaction, a few plants did show strong reactions. Mixed infection with CPLV and CCDV was observed in two plants collected from IC fields.

**Transmission studies**. All chickpea plants (collected from ICRISAT fields) showing weak reaction with CPLV antiserum were pooled and stored at -70°C. The virus was purified from 200 g tissue. Purified virus was suspended in 0.01 M phosphate buffer containing 5% sucrose and was used to feed *Myzus persicae* and *Aphis craccivora*. After 1 day acquisition, aphids were released onto young pea seedlings and *Physalis floridana*. After an inoculation access of 2 days, the aphids were killed by spraying them with insecticides. The exposed plants were maintained in a greenhouse. All the inoculated plants were tested after three weeks by ELISA using a potato leaf roll virus (PLRV) monoclonal antibody, A12, that has shown broad specificity with several luteoviruses. Results showed that *Myzus persicae*, but not *Aphis craccivora*, transmitted the virus to peas and to *Physalis floridana*. Analysis of the plants individually with a panel of PLRV and barley yellow dwarf virus specific McAbs revealed three distinct patterns of reaction suggesting that the purified virus obtained from field-collected chickpea plants was a mixture of distinct strains of a luteovirus or of different luteoviruses. We are currently carrying out additional transmission studies with *Myzus persicae* to establish pure cultures of these virus isolates. These cultures will then be utilized to study their reaction in chickpea and for further characterization using McAbs and nucleic acid probes.

**Tissue Culture**. A collaborative project was initiated with the Cell Biology Unit to maintain cultures of chickpea luteoviruses by tissue culture methods. A protocol for micropropagation of chickpea from shoot tip explants developed by the Cell Biology Unit was adapted for this purpose. Shoot tips and nodal stem cuttings (1-2 cm long) from chickpea plants with "stunt-like" symptoms that were positive for CPLV antiserum were cultured on ML-6 medium containing 2.0 mg $L^{-1}$ benzyladenine (BA) and 0.5 mg $L^{-1}$ indole acetic acid (IAA). After 4 weeks, individual shoots were excised and tested by DAS-ELISA for luteovirus. The luteovirus-positive shoots were transfered onto fresh medium. Multiple shoots and shoot buds were produced from these shoots without shoot elongation. The virus could be detected by DAS-ELISA in these shoots. Callus induced from the base of the shoot explants was subcultured separately and the new callus produced was positive for luteovirus in DAS-ELISA. Thus the results obtained so far indicate that the tissue culture approach could help to maintain the chickpea luteoviruses in callus and in shoots. Work is in progress to transmit the virus *Myzus persicae* from callus onto chickpea plants for further characterization.

**LP-501(90)IC/IC: Characterization and diagnosis of the causal agent of sterility mosaic disease of pigeonpea**

**Scientist: DVRR**

No research done in this quarter.

**LG-851(90)IC/IC: Characterization of isolates of bud necrosis virus (BNV), epidemiology, and management of bud necrosis disease**

**Scientists: DVRR, AAMB**

**Resistance to Peanut Bud Necrosis Virus (PBNV)**

The $F_2$ progeny of a half diallel between five PBNV-resistant and two-susceptible entries were sown together with the parents in the postrainy season of 1992/93. The infection of PBNV is currently being recorded at 2-week intervals. The $F_2$ will be advanced to $F_3$ using the single seed descent method. Additional crosses between entries with resistance to the vector and susceptible entries have been made for studying the inheritance of vector resistance.

The unfolded third leaf of each plant of JL 24 (susceptible), ICGV 86031 (resistant), and ICGV 86388 (resistant) were mechanically inoculated (with $10^{-1}$ dilution) in a greenhouse. The presence of symptoms on the inoculated leaves and on the noninoculated leaves was recorded daily. Furthermore, virus concentration was measured in the systemically infected leaves utilizing triple antibody sandwich (TAS) ELISA using polyclonal antibody, McAbs produced for PBNV and alkaline phosphatase (ALP) labelled antimouse IgG. Time taken (in days) for the appearance of systemic symptoms, the percentage of symptomatic leaves, the developmental stage of the leaf, and the leaf number that showed first systemic symptoms were recorded for each sample. JL 24 reached an average incidence of 80% whereas ICGV 86031 reached 22.3% and ICGV 86388 17.7%. The analysis of the ELISA data is still in progress, but preliminary results show that although the resistant entries had a lower incidence than JL 24, the systemically infected leaves of all three entries tested showed similar virus concentration in ELISA. This indicated that the virus multiplied at a comparable rate in these entries when systemic infection occurred. The lower incidence is assumed to be due to lack of translocation of the virus following multiplication in the inoculated leaflet. Initial virus replication and subsequent translocation are probably influenced by the amount of virus concentration utilized in inoculation.

In a second experiment JL 24, ICGV 86031, and ICGV 86388 were inoculated in the greenhouse at 12, 20, 32, and 42 days after sowing (DAS). The youngest unfolded leaf of each plant was inoculated. The incidence and position of the first leaf showing systemic symptoms were recorded. The incidence declined rapidly in all entries with increasing age of the plant (**Table 36**). This phenomenon of adult plant resistance was also be observed under field conditions. Date of sowing trials to avoid high virus incidence were aimed at utilizing adult plant resistance under field conditions.

**Table 36. The mean PBNV incidence (%) and standard deviation (s.d.) after mechanical inoculation of the youngest unfolded leaf of JL 24, ICGV 86031, and ICGV 86388 on 12, 20, 32, and 42 days after sowing (DAS).**

| | Days after sowing | | | |
|---|---|---|---|---|
| Entry | 12 | 20 | 32 | 42 |
| JL 24 | 97.1[1] | 8.0 | 1.5 | 0.0 |
| | (4.2)[2] | (6.9) | (2.6) | (0.0) |
| ICGV 86031 | 13.7 | 0.7 | 0.0 | 0.0 |
| | (13.7) | (1.2) | (0.0) | (0.0) |
| ICGV 86388 | 4.7 | 1.4 | 0.0 | 0.0 |
| | (1.6) | (1.2) | (0.0) | (0.0) |

1. Mean percentage incidence of two replications.
2. Figures in parentheses are standard deviations.

**Production of monoclonal antibodies**

Six bud necrosis disease field-resistant lines supplied by Dr S.L. Dwivedi to be screened for PBNV resistance under greenhouse conditions were sown in four replications, with 20 plants per replicate. Plants were inoculated at the third quadrifoliate leaf stage with $10^{-2}$ dilution of virus. ICGV 86388 and 86029 showed 15-17% PBNV incidence whereas JL 24 showed 78% incidence (average of four replications).

Fluid from ascite tumors were collected from 4 mice 2 weeks after injecting with hybridomas specific for peanut mottle (PMV) and peanut green mosaic (PGMV) viruses. When tested for specificity, the antibodies reacted only with the respective viruses for which they are produced. Dr Lesley Torrence of SCRI spent 2 weeks in the monoclonal antibody laboratory as a consultant to demonstrate fusion and screening. Purified PBNV was used for immunizing mice. For the first immunization, PBNV was mixed with an equal volume of Freunds' complete adjuvant and for the subsequent immunizations, PBNV was mixed with an equal volume of Freunds' incomplete adjuvant. Mice were bled after the third immunization and titer of the serum was checked by DAC-ELISA for selecting suitable splenocytes in fusion experiments. Revived myeloma cell-line SP2/0 Ag.14 and also nine PBNV specific hybridoma cell-lines. Sp2/0 Ag.14 cell-line was frozen and stored at -90°C.

**LG-852(90)IC/IC: Development of detection methods and management of peanut clump virus disease**

**Scientists: DVRR, RAN, VW**

Virus detection and groundnut tests were conducted on seed collected from HIPCV infected groundnut.

Seeds obtained from plants grown in peanut clump virus infested soil during the rainy season on field RCW 17A were tested for virus presence by ELISA with the following results.

**Experiment No. 1**

Seed testing
(Testa, embryo, and cotyledon)

Results of ELISA test

| Testa | Embryo | Cotyledon |
|---|---|---|
| 21 (+) | 2 (+) | 2 (+) |
| 41 (-) | 60 (-) | 60 (-) |

+ indicates positive reaction.
- indicates negative reaction.

**Experiment No. 2**

Results of growout tests

| No. of seeds | Seed test by ELISA | Growing out test | Seedlings by ELISA |
|---|---|---|---|
| 186 | 20 + | 17 + | 17 + |
| | 156 - | 156 - | 156 - |
| | 10 + | 10 - | 10 - |

+ indicates positive reaction.
- indicates negative reaction.
± indicates doubtful reaction.

During this quarter, our efforts were focused mainly on analysis of the RNA 2 specific cDNA clones of the Indian peanut clump virus-Hyderabad isolate (HIPCV) for the detection of other IPCV isolates. Two large clones namely pPCV356 (1.1 kilo bases) and pPCV324(2.2 kilo bases) which together represent about 90% of the IPCV RNA 2 were used for the Northern and dot blot hybridization

The pPCV324 clone was digested with restriction enzymes PstI and SalI and the three fragments obtained were gel isolated and subcloned into plasmid pUC119 at the appropriate restriction enzyme sites. The pPCV356, pPCV324a (415 basepairs), pPCV324b (878 basepairs) and pPCV324c (600 basepairs) clones (**Fig. 11**) were labelled separately with $^{32}P$ by the "oligo-labelling" method and used as probes in Northern and dot-blot hybridisations (Legumes Program Quarterly Technical Report, Oct-Dec 1992, p 65). Results showed that the pPCV356 and pPCV324a reacted strongly with HIPCV, weakly with TIPCV, and poorly with LIPCV. Although clones pPCV324b and pPCV324c reacted with all the IPCV isolates the signal was stronger with clone pPCV324c. Thus clone pPCV324c can be used to detect all the currently identified IPCV isolates. Encouraged by this finding we are currently testing various non-radioactive labelling procedures utilizing pPCV324c clone for the detection of IPCV isolates.

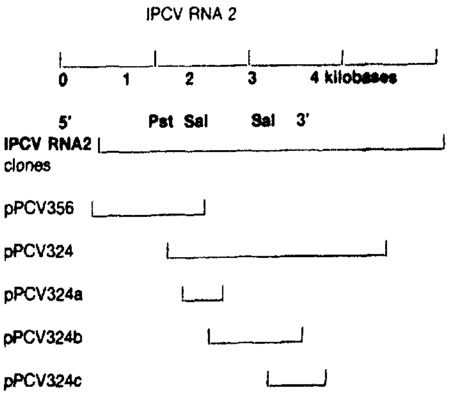


*Figure 11. Diagramatic representation of different cDNA clones used in dot blot hybridization studies.*

**LG-853(90)IC/IC: Development of detection methods and identification of genotypes with resistance to peanut mottle virus**

**Scientist: DVRR**

**Surveys for PStV and PMV**

Dr M.S. Basu brought 17 PStV-suspected samples from Navsari. The material originated from Junagadh. All samples were tested by DAC ELISA. Four samples showed positive reaction to both PMV and PStV and six samples to PStV alone. One sample showed positive reaction to CMMV.

A survey was conducted under the ICAR/ICRISAT collaborative research project, from 22 to 28 Mar 1993, for peanut stripe virus in AICORPO trials and farmers' fields in the northeastern regions (Pulses and Oilseeds Research Station, and two farmers' fields at Berhampur; Assam Agricultural College campus, Central Research Institute for Jute and Allied Fibres, and the farmers' fields at Jorhat) of India. No PStV was found except on the Assam Agricultural University farm located at Jorhat.

We have surveyed all the groundnut genotypes in the fields RP 10B and RP 10C currently maintained by GRU for symptoms produced by seedborne viruses. These scorings were carried out from 9 to 18 Feb 1993. All suspected samples were tagged and tested by ELISA using PMV and PStV antisera. Fifty-four samples were positive to PMV in five genotypes and these plants were destroyed.

On request from Dr S.N. Nigam we have surveyed field RP 8C for the seedborne viruses, PMV and PStV. Eight suspected samples were collected and tested by ELISA. None of the samples contained PMV or PStV viruses.

**LG-855(90)IC/IC: Identification of minor diseases of groundnut caused by viruses, prokaryotes and viroids**

**Scientists: DVRR, RAN, PB**

In host range studies, *Nicotiana tabacci* (White Burley), *N. rustica* and *N. benthamiana* could not be infected with "Aliyarngar" virus (ALNV).

In tests to determine serological relationships, ALNV did not react with two samples of bean pod mottle virus antisera.

## ICRISAT/ICARDA Joint Chickpea Project

**LC-036(90)IC/IC: Screening cultivated and wild *Cicer* species for resistance to biotic and abiotic stresses**

**Scientist: KBS**

Screening for cold tolerance was completed. Severity of cold was less than in the previous three seasons, but was enough to kill the susceptible control. Data are being compiled.

Screening for drought has been strengthened from this year. On 20 Mar, 2000 new germplasm accessions, 3000 $M_2$ progenies, and over 200 accessions of eight annual *Cicer* species have been sown. In addition, lines found tolerant to drought during the 1992 screening were sown at two locations (Tel Hadya and Breda) and under two conditions (with and without supplemental irrigations). It is hoped that the delay of sowing by about a month will provide an opportunity to screen germplasm and breeding materials effectively.

Efforts are underway to develop a 2 ha wilt-sick plot. This is the fourth time sowing has been done in this plot with susceptible cultivars and the second time with inoculation. At the end of this sowing, the plot was infested throughout with wilt disease. In an area of 0.25 ha all plants were killed by the disease. It is expected that by two more sowings with a susceptible cultivar and disease inoculation, the field should be uniformly infested by the pathogen and ready for use in resistance screening.

### LC-037(90)IC/IC: ICRISAT/ICARDA kabuli chickpea breeding

**Scientist: KBS**

Spring sowing of segregating generations, including 276 $F_6$ and 8395 $F_5$ progenies, 10 $F_4$ and 20 $F_2$ populations, was completed in the last week of February at Tel Hadya.

International (CIYT-Sp, CISN-Sp) and preliminary yield trials were sown at Tel Hadya, Jindiress, and Terbol. Germination seems to be satisfactory despite the 1992/93 season being dry so far.

The materials segregating for leaf miner resistance were also sown Included in them were 10 $F_3$ populations and 643 $F_4$, and 180 $F_6$ progenies.

### LC-038(90)IC/IC: Germplasm enhancement for individual traits and combinations of traits

**Scientist: KBS**

There is nothing specific to report in this quarter, except that materials for all the four subprojects have been sown.

### LC-039(90)IC/IC: Transfer of genes for resistance to biotic and abiotic stresses from wild to cultivated species

**Scientist: KBS**

Although all the data collected on interspecific hybridization for the transfer of genes for cold tolerance from wild to cultivated species have not been collected, the results are highly encouraging. A few of the $F_6$ progenies have shown resistance to cold at all three test locations. In addition, some of them are already flowering, whereas none of the check cultivar are flowering. Therefore, it is obvious that genes for both cold tolerance and early flowering can be transferred from *C. echinospermum* and *C. reticulatum.*

## Eastern Africa Regional Cereals and Legumes Program (EARCAL)

### On-going Experiments

### Short-duration pigeonpea trials

Short-duration pigeonpea trials are aimed at evaluating the performance and adaptation of pigeonpea to the eastern Africa conditions. The EARCAL project on pigeonpea aims at introducing well adapted cultivars with acceptable pod and grain characters in diverse agroecological zones both as a subsistence and a commercial crop.

### Observation nursery

One hundred and twenty-one newly introduced short-duration lines were sown in late Oct 1992 as an observation nursery in four environments which varied in temperature and moisture supply. At Kiboko (980 m asl and high mean temperature), most lines were over 1 m tall, and except for four lines, all have matured and are being harvested. At Katumani (1540 m asl and intermediate mean temperature), most lines were 30-60 cm tall and the short-duration lines have matured. At the University of Nairobi, (about 1800 m asl, low mean temperature) all lines were shorter than 50 cm and are still in the pod filling stage.

The preliminary results indicate that both plant height and time to maturity are influenced by temperature, with low temperature reducing plant height and delaying maturity.

### Preliminary yield trial

Forty-nine promising lines from the previous season's trials were sown in a preliminary yield trial at Kiboko (rainfed and assured moisture conditions) and Kibwezi (rainfed). At both locations, plant height was over 1 m and most have been harvested. The most promising lines are being constituted into the "Regional Adaptation Trial" that will be sent to collaborators in eastern Africa.

### Adaptation trial

Twelve promising lines of short-duration pigeonpea were constituted into a 'Short-duration pigeonpea adaptation trial' and sent to collaborators in Kenya and Uganda. A set was also sown at our station at Kiboko in late Oct 1992. Plant height at flowering varied between 50 and 70 cm, and at maturity between 1.0 and 1.5 m. Most lines have been harvested.

### Medium- and long-duration pigeonpea trial

Medium- and long-duration pigeonpea trials aim at evaluating the performance and adaptation of pigeonpea to the conditions in the region. The project aims at developing from landraces and introduced germplasm superior and well adapted cultivars with acceptable seed characters for sole cropping, inter-cropping and agroforestry.

All trials have been sown at Kiboko, Kibwezi, Kampi ya Mawe, and the University of Nairobi.

In general crop stands of long-duration lines are poorer than those of short-duration genotypes. Among the long-duration lines, landraces had poorer plant stands than the lines obtained from IC.

Landraces collected during the survey were sown in Kibwezi and Kiboko. We established a wilt-sick plot at Kiboko using plant material collected from the survey.

### Adaptation to temperature and photoperiod

Forty-eight lines of diverse origin were sown in Nov 1992 at Kiboko (980 m asl), Katumani (1540 m asl) and the University of Nairobi (about 1800 m asl) under natural and extended (14 h) photoperiod. Mean height at Kiboko was about 2 m, at Katumani was 1.2 m, and at the University of Nairobi was 0.9 m.

### Long photoperiod suppressed flowering

Under natural daylength, Nairobi with lowest mean temperature had over 90% of the lines in flowering, followed by Katumani with intermediate temperature; Kiboko with high mean temperature had the lowest percentage of cultivars that had flowered.

**Observation and drought tolerance screening nursery**

At Kiboko 100 lines of medium-duration pigeonpea and at Kibwezi (Masongaleni) 100 lines of long-duration pigeonpea were sown in early November and are being grown under rainfed and supplementary irrigation. The trials aim at identifying superior lines of medium- and long-duration pigeonpea as a rainfed crop and selecting lines with tolerance to drought. All medium-duration lines are in the reproductive stage of development, while most long-duration lines are still in the vegetative stage of growth.

**Sustainability and intercropping experiments**

A trial to determine the role of pigeonpea and short-duration legumes in sustainability of cereal-based cropping systems of dry areas of Kenya was sown at Kampi ya Mawe (1100 m asl). This is a 10-year study and a joint program between ICRISAT and KARI. Early- season drought resulted in delayed establishment. Maize, sorghum, short-duration pigeonpea, and cowpea are being harvested.

# Technology Exchange

## Chickpea

### LC-018(90)IC/IC: International trials and nurseries

**Scientists: HAvR, OS, SCS, JK**

The procedure followed at ICRISAT in supplying materials for international trials and nurseries has worked well over the years, but on several occasions suggestions were made by various NARS to further improve collaborative links. Accordingly it was decided to write to collaborators seeking their active participation and support in conducting trials. Iran sent seed samples of kabuli cultivars for inclusion in international trials, and so did the Haryana Agricultural University. The International trials and nursery sets sown at IC, performed well giving high yields under nonirrigated conditions and the coefficient of variations were low (**Table 1**). Also the AICPIP trials, sown with irrigation (as the seed of these was received late), performed well.

### LC-019(90)IC/IC: Transfer of information and technology

**Scientists: HAvR, OS, SCS, JK**

As planned, three exploratory trips were jointly made by crop quality, RMP-Economics, and chickpea breeding scientists to Lam-Guntur, Andhara Pradesh, Akola, Maharashtra; and KRIBHCO, Baroda, Gujarat; and surrounding areas to monitor adoption and spread of released and recommended chickpea varieties. All trips were useful as they revealed that in certain areas (Maharashtra) the adoption was faster than in others; that marketing problems sometimes formed obstacles to wider adoption (Andhara Pradesh) and that non-traditional chickpea production areas could well transform into chickpea-growing areas (Gujarat). The exploratory activities were not only useful in obtaining data on adoption of ICRISAT/NARS-developed material, but also in planning further strategies for impact studies.

It was perceived from suggestions made by collaborators that in the future there will be increased demands for chickpea varieties that can be harvested mechanically. We therefore began to shift selection emphases towards medium-tall types and have planned to provide trial sets with material that possesses the desired trait.

S.C. Sethi presented a paper entitled "Breeding for botrytis gray mold resistance at ICRISAT" by S.C. Sethi, Onkar Singh, and Henk A. van Rheenen at the Botrytis Gray Mold Group Meeting in Nepal 13-17 Mar.

Henk A. van Rheenen coordinated chickpea polygon breeding activities of the TNAU - Coimbatore; ARS (AICPIP), Badnapur; and APAU - Lam/Guntur, by visiting Coimbatore on 11 Jan, Aruppukkottai and Kovilpatti on 12 Jan, Badnapur on 20 Jan, and Parbhani on 21 Jan and having field visits with staff of the institutions mentioned at IC on 28 and 29 Jan.

Similarly, Onkar Singh coordinated chickpea polygon breeding activities of PKV - Akola; JNKVV - Sehore by visiting Akola on 17 Feb, Sehore on 18 Mar and by receiving the collaborator from Sehore at IC on 16 Feb.

**ICRISAT/ICARDA Joint Chickpea Project**

**LC-040(90)IC/IC: International trials and nurseries of Kabuli Chickpea**

**Scientist: KBS**

The people's Republic of China has released two chickpea cultivars, namely "FLIP 81-40W" and "FLIP 81-71", from the materials supplied through the project. With these two releases, the number of cultivars released by national programs has reached 50 in 17 countries.

## Pigeonpea

**LP-300(90)IC/IC: International pigeonpea trials and nurseries**

**Scientists: RPA, KBS, KCJ, NBS**

Seed was supplied to 14 countries during this quarter as a part of our technology exchange program. We supplied 88 samples of advanced lines on request to 10 countries. Released varieties were also supplied to 11 countries among which 26 requests were from Indian NARS. Segregating populations were supplied to two countries. The distribution of seed materials during the quarter is shown in **Table 37.**

**Table 37. Summary of pigeonpea seed supplied from 1 January to 31 March 1993.**

| Country | Trials | Released varieties | Advanced lines | Male steriles | Others | Segregating material | Germplasm accessions |
|---|---|---|---|---|---|---|---|
| Bangladesh | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| PR China | 0 | 4 | 10 | 0 | 0 | 0 | 3 |
| Egypt | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| India | 0 | 26 | 42 | 1 | 5 | 0 | 13 |
| Indonesia | 0 | 3 | 6 | 0 | 0 | 0 | 0 |
| Laos | 0 | 1 | 8 | 0 | 2 | 0 | 3 |
| Mauritania | 0 | 0 | 3 | 0 | 0 | 0 | 1 |
| Philippies | 0 | 1 | 7 | 0 | 0 | 0 | 0 |
| Zimbabwe | 0 | 3 | 4 | 0 | 0 | 2 | 7 |
| Senegal | 0 | 3 | 3 | 0 | 0 | 2 | 1 |
| Sierra Leone | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Thailand | 0 | 2 | 3 | 0 | 0 | 0 | 1 |
| Uganda | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| United Kingdom | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total | 4 | 47 | 88 | 1 | 7 | 4 | 30 |

**International Trials**

Data from international trials were received from 18 locations in 6 countries. These are discussed by country below:

**Brazil**

Two experiments were conducted at Santa Catarina, Brazil, in the 1991/92 season. Both were sown on 12 Nov 1991 and the Extra-short-duration Pigeonpea International Trial (EXPIT) cultivars were harvested during Mar-Apr 1992, while the short-duration Pigeonpea International Trial (EPIT) material was harvested during Apr-Jun. Santa Catarina is located at 27° 62' south latitude at an altitude of 670 m. Our collaborator Mario Miranda indicated that even the determinate cultivars tended towards indeterminancy and harvesting posed difficulties in view of merging of productive stages.

Examination of the rainfall data revealed that the trial location was situated in a high rainfall area. The total rainfall received during the cropping period was 1500 mm with 499 mm received in February alone. The EPIT cultivars had experienced another heavy rainfall in May (483 mm) which, being close to maturity, could have triggered new flushes of flowers and vegetative growth.

Despite the wet conditions throughtout the cropping period, the extra- short-duration cultivars (EXPIT) ICPLs 84023, 88009, 4, and 90012 gave yields exceeding 1 t $ha^{-1}$ (**Table 38**).

**Table 38. Performance of pigeonpea entries in EXPIT 91 DT grown at Santa Catarina, Brazil, 1991/92.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield (t $ha^{-1}$) |
|---|---|---|---|---|---|---|
| ICPL 84023 | 62 | 121 | 103 | 8.0 | 75 | 1.32 |
| ICPL 88009 | 74 | 126 | 133 | 9.7 | 66 | 1.28 |
| ICPL 4 | 65 | 121 | 115 | 6.7 | 78 | 1.15 |
| ICPL 90012 | 65 | 126 | 107 | 10.4 | 46 | 1.04 |
| ICPL 88007 | 65 | 124 | 97 | 9.7 | 69 | 1.02 |
| ICPL 89024 | 63 | 123 | 85 | 9.2 | 68 | 0.99 |
| ICPL 83015 | 63 | 123 | 105 | 9.1 | 67 | 0.99 |
| ICPL 90011 | 67 | 124 | 113 | 12.2 | 54 | 0.99 |
| ICPL 88001 | 70 | 135 | 115 | 10.5 | 66 | 0.95 |
| ICPL 90008 | 62 | 123 | 93 | 9.6 | 76 | 0.94 |
| ICPL 87095 | 66 | 126 | 100 | 9.1 | 63 | 0.88 |
| ICPL 90001 | 69 | 128 | 107 | 11.0 | 63 | 0.77 |
| ICPL 88015 | 65 | 122 | 93 | 9.5 | 49 | 0.66 |
| ICPL 85010 | 61 | 119 | 93 | 9.1 | 87 | 0.64 |
| ICPL 88017 | 63 | 117 | 87 | 9.4 | 60 | 0.61 |
| ICPL 88003 | 59 | 123 | 93 | 9.4 | 55 | 0.60 |
| ICPL 90004 | 63 | 121 | 107 | 10.3 | 67 | 0.57 |
| ICPL 89027 | 63 | 126 | 98 | 10.8 | 55 | 0.54 |
| ICPL 89020 | 58 | 117 | 95 | 9.6 | 57 | 0.46 |
| ICPL 90005 | 57 | 115 | 83 | 8.9 | 59 | 0.09 |
| SE | ±1.0 | ±3.1 | ±3.5 | ±0.18 | ±8.8 | ±0.116 |
| Mean | 64.1 | 122.9 | 101.2 | 9.61 | 64.0 | 0.82 |
| CV (%) | 2.6 | 4.4 | 6.0 | 3.25 | 23.7 | 24.3 |

Among the short-duration cultivars (EPIT), 10 entries gave over 1 t ha⁻¹ yield. Varietal differences within each duration group for days to flowering, maturity and plant height were noticed.

In the extra-short-duration group, cultivars ICPLs 88007, 89024, 90008, 88015, 85010, 88017, 89030, 89027, and 90005 grew to less than 1 m height, flowered and matured at about the same duration they did at Patancheru. The high latitude and altitude of Santa Catarina appears to have had little influence on the three parameters mentioned.

The sensitivity of the short-duration cultivars to higher latitude and altitude was more marked. Among them some took about 200 days to reach maturity (**Table 39**). But ICPLs 151, 85012, 86012, 90024, 87104, and 88025 had flowered in 70 to 82 days and had matured in 128 to 136 days. Since the duration of these cultivars at Patancheru is not too dissimilar, it is presumed that high soil moisture, photoperiod, temperature etc., have had little influence on their phenology. Furthermore their heights at Santa Catarina conditions were not very different from those at Patancheru. ICPL 88025 in particular had not grown any taller than it did at IC.

**Table 39. Performance of pigeonpea entries in EPIT 91 DT grown at Santa Catarina, Brazil, 1991/92.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield ($t\ ha^{-1}$) |
|---|---|---|---|---|---|---|
| ICPL 88023 | 96 | 210 | 172 | 14.0 | 40 | 1.46 |
| ICPL 90029 | 93 | 186 | 167 | 17.4 | 41 | 1.41 |
| ICPL 89030 | 85 | 158 | 143 | 11.9 | 47 | 1.34 |
| ICPL 87101 | 91 | 203 | 178 | 13.9 | 42 | 1.31 |
| ICPL 84031 | 86 | 192 | 155 | 11.0 | 49 | 1.24 |
| ICPL 90013 | 81 | 136 | 145 | 11.3 | 30 | 1.22 |
| ICPL 86005 | 89 | 187 | 158 | 13.5 | 55 | 1.20 |
| ICPL 87105 | 91 | 203 | 173 | 12.1 | 41 | 1.15 |
| ICPL 87 | 89 | 195 | 150 | 11.6 | 53 | 1.12 |
| ICPL 90028 | 94 | 213 | 158 | 14.8 | 42 | 1.07 |
| ICPL 151 | 82 | 128 | 120 | 11.6 | 45 | 0.91 |
| ICPL 85012 | 73 | 132 | 112 | 12.3 | 30 | 0.86 |
| ICPL 88027 | 85 | 180 | 152 | 12.1 | 55 | 0.85 |
| ICPL 86012 | 76 | 134 | 137 | 13.0 | 50 | 0.57 |
| ICPL 90024 | 81 | 128 | 123 | 11.1 | 18 | 0.54 |
| ICPL 87104 | 79 | 136 | 130 | 13.2 | 39 | 0.53 |
| ICPL 83024 | 83 | 146 | 147 | 14.9 | 44 | 0.39 |
| ICPL 89031 | 77 | 93 | 113 | 15.4 | 39 | 0.37 |
| ICPL 88025 | 75 | 110 | 110 | 14.7 | 47 | 0.29 |
| ICPL 87109 | 90 | 178 | 165 | 14.1 | 41 | 0.26 |
| SE | ±1.6 | ±6.2 | ±3.3 | ±0.28 | ±6.0 | ±0.197 |
| Mean | 84.8 | 162.5 | 145.4 | 13.20 | 42.3 | 0.90 |
| CV (%) | 3.2 | 6.6 | 3.9 | 3.70 | 24.6 | 37.7 |

**Thailand**

For the second successive year, the identical extra-short- (EXPIT) and short-duration (EPIT) trials were conducted at Khon Kaen in 1992. For reasons that are not clear, the cultivars in both trials matured at the same time. Both trials were sown on 8 Sep 1992, and flowered in around 55 days. Harvesting was done on 11 Jan 1993.

No rains were received in November, and the total rainfall during the growing periods probably did not exceed 500 mm. The crop was irrigated whenever needed. All the test cultivars of the extra-short-duration trial (EXPIT 92) performed well with all but seven cultivars yielding more than 2 t $ha^{-1}$ (**Table 40**). ICPL 88009 and ICPL 88015, the two highest yielding lines in the 1991 trial, gave yields exceeding 2 t $ha^{-1}$ in 1992.

Among the entries of the short-duration trial (EPIT 92), all but one gave yields in excess of 2 t $ha^{-1}$, and 5 in excess of 3 t $ha^{-1}$ (**Table 41**). ICPL 90013 and 88027 had performed very well in 1991 as well. The mean plant height of cultivars in the extra-short-duration group was 66.5 cm and in the short-duration group it was 68.7 cm.

Siamati Ltd., a private enterprise has identified ICPL 151 and ICPL 83009 for commercial cultivation in Chiang Mai Province. In 1992 Siamati sponsored cultivation of the two cultivars on about 18 ha. In 1993 they intend raising the cultivated area to 200 ha.

**Table 40. Performance of pigeonpea entries in EXPIT 92 DT grown at Khon Kaen, Thailand, 1992.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield (t $ha^{-1}$) | Dry matter yield (t $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| ICPL 88017 | 58 | 110 | 103 | 9.2 | 66 | 2.94 | 14.11 |
| ICPL 90012 | 56 | 110 | 72 | 9.6 | 65 | 2.85 | 13.43 |
| ICPL 90008 | 57 | 110 | 70 | 7.7 | 67 | 2.75 | 13.47 |
| ICPL 88009 | 56 | 110 | 66 | 10.3 | 69 | 2.71 | 13.20 |
| ICPL 4 | 57 | 110 | 66 | 6.5 | 68 | 2.60 | 11.57 |
| ICPL 88015 | 57 | 110 | 73 | 8.8 | 65 | 2.37 | 10.63 |
| ICPL 84023 | 57 | 110 | 67 | 8.9 | 68 | 2.36 | 13.53 |
| ICPL 90011 | 58 | 110 | 68 | 10.9 | 66 | 2.27 | 11.40 |
| ICPL 90012 | 58 | 110 | 66 | 10.7 | 67 | 2.23 | 10.91 |
| ICPL 83015 | 58 | 110 | 64 | 8.5 | 65 | 2.17 | 11.38 |
| ICPL 88001 | 58 | 110 | 65 | 9.8 | 66 | 2.17 | 10.77 |
| ICPL 87095 | 57 | 110 | 57 | 9.0 | 68 | 2.14 | 11.32 |
| ICPL 85010 | 58 | 110 | 64 | 8.5 | 67 | 2.09 | 10.92 |
| ICPL 88003 | 56 | 110 | 66 | 10.2 | 69 | 1.93 | 9.22 |
| ICPL 88015 | 57 | 110 | 58 | 10.1 | 68 | 1.89 | 9.33 |
| ICPL 89027 | 58 | 110 | 63 | 9.5 | 68 | 1.87 | 8.64 |
| ICPL 90004 | 57 | 110 | 66 | 9.5 | 66 | 1.87 | 8.82 |
| ICPL 89020 | 56 | 110 | 59 | 10.1 | 68 | 1.79 | 8.98 |
| ICPL 90005 | 58 | 110 | 66 | 10.2 | 66 | 1.64 | 8.15 |
| ICPL 89024 | 57 | 110 | 52 | 7.6 | 67 | 1.64 | 9.07 |
| SE | ± 0.4 | ± 0.0 | ± 2.5 | ± 0.26 | ± 1.4 | ± 0.235 | ± 0.371 |
| Mean | 57.3 | 110.0 | 66.5 | 9.29 | 66.9 | 2.21 | 10.942 |
| CV (%) | 1.3 | 0.0 | 6.4 | 4.76 | 3.6 | 18.4 | 5.880 |

Table 41. Performance of pigeonpea entries in EPIT 92 DT grown at Khon Kaen, Thailand, 1992.

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield (t $ha^{-1}$) | Dry matter yield (t $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| ICPL 87105 | 57 | 110 | 65 | 11.2 | 68 | 3.19 | 16.95 |
| ICPL 85012 | 56 | 110 | 71 | 10.9 | 68 | 3.17 | 17.89 |
| ICPL 90013 | 56 | 110 | 79 | 10.6 | 68 | 3.11 | 13.81 |
| ICPL 88027 | 57 | 110 | 66 | 10.2 | 66 | 3.10 | 17.84 |
| ICPL 88025 | 58 | 110 | 70 | 11.3 | 67 | 3.02 | 16.54 |
| ICPL 84031 | 58 | 110 | 76 | 9.7 | 68 | 2.95 | 16.34 |
| ICPL 83024 | 54 | 110 | 82 | 14.4 | 68 | 2.95 | 12.78 |
| ICPL 87101 | 56 | 110 | 71 | 12.6 | 67 | 2.91 | 12.62 |
| ICPL 90024 | 58 | 110 | 70 | 10.0 | 68 | 2.64 | 12.33 |
| ICPL 90029 | 57 | 110 | 66 | 13.6 | 66 | 2.60 | 11.84 |
| ICPL 88023 | 57 | 110 | 58 | 12.6 | 70 | 2.58 | 12.31 |
| ICPL 89030 | 56 | 110 | 72 | 11.1 | 66 | 2.52 | 12.21 |
| ICPL 89031 | 55 | 110 | 64 | 12.8 | 67 | 2.49 | 11.43 |
| ICPL 151 | 57 | 110 | 56 | 10.9 | 68 | 2.48 | 11.31 |
| ICPL 86012 | 56 | 110 | 74 | 11.4 | 68 | 2.30 | 9.50 |
| ICPL 90028 | 57 | 110 | 73 | 13.6 | 67 | 2.22 | 10.89 |
| ICPL 87109 | 55 | 110 | 73 | 12.8 | 68 | 2.13 | 9.54 |
| ICPL 87 | 57 | 110 | 62 | 11.0 | 69 | 2.12 | 12.16 |
| ICPL 87104 | 58 | 110 | 66 | 11.4 | 67 | 2.12 | 11.67 |
| ICPL 86005 | 56 | 110 | 60 | 12.6 | 66 | 1.56 | 10.04 |
| SE | ±0.5 | ±0.0 | ±2.1 | ±0.32 | ±1.3 | ±0.236 | ±0.606 |
| Mean | 56.6 | 110.0 | 68.7 | 11.73 | 67.5 | 2.61 | 13.000 |
| CV (%) | 1.5 | 0.0 | 5.2 | 4.69 | 3.3 | 15.7 | 8.071 |

**Israel**

Yield, yield components, and growth characteristics of 16 short-duration lines were evaluated at Bet Dagan in Israel during 1992. The trial was sown on the 2 Apr at the commencement of the dry period and so received hardly any rainfall during the cropping season. The crop was drip irrigated at the seedling stage, and thereafter at regular week intervals as and when needed.

ICPL 83024 yielded 4.38 t $ha^{-1}$, ICPL 87101 3.35 t $ha^{-1}$ and ICPL's 87104, 87105, 84031, 86007 over 2 tons $ha^{-1}$ (**Table 42**). Although days to flowering was almost similar to that of Patancheru (57 to 74 days), days to maturity in some cases e.g., for ICPL 83024 was much longer. This cultivar was also the tallest among the test materials. Most of the cultivars grew to heights of less than a meter. The effect of long-duration and short growth habit were probably due to the influence of temperature during crop growth.

**Tanzania**

The extra-short-duration determinate pigeonpea trial (EXPIT DT) was conducted at 5 locations in Tanzania during the 1991/92 growing season.

**Table 42. Performance of entries in short-duration pigeonpea trial grown at Bet Dagan, Israel, 1992.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | Pods per plant | Seeds per pod | 100-seed weight (g) | Grain yield (t $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| ICPL 83024 | 66 | 166 | 156 | 169 | 5.0 | 9.0 | 4.38 |
| ICPL 87101 | 74 | 154 | 138 | 93 | 6.2 | 12.7 | 3.35 |
| ICPL 87104 | 58 | 142 | 89 | 88 | 5.1 | 11.9 | 2.99 |
| ICPL 87105 | 62 | 158 | 76 | 90 | 4.9 | 9.2 | 2.57 |
| ICPL 84031 | 59 | 135 | 72 | 101 | 5.1 | 9.5 | 2.53 |
| ICPL 86007 | 60 | 133 | 41 | 79 | 4.4 | 11.3 | 2.36 |
| ICPL 87108 | 64 | 141 | 74 | 135 | 5.0 | 14.8 | 1.93 |
| ICPL 86029 | 59 | 124 | 59 | 74 | 4.0 | 7.6 | 1.58 |
| ICPL 87102 | 60 | 139 | 74 | 83 | 5 3 | 12.0 | 1.58 |
| ICPL 86012 | 62 | 139 | 100 | 124 | 5.9 | 11.4 | 1.54 |
| ICPL 85012 | 60 | 126 | 65 | 75 | 5.0 | 10.7 | 1.22 |
| ICPL 87109 | 62 | 134 | 54 | 48 | 4.6 | 13.9 | 1.09 |
| ICPL 87 | 58 | 132 | 52 | 68 | 4.4 | 11.5 | 1.07 |
| ICPL 86005 | 57 | 128 | 46 | 71 | 4.7 | 10.8 | 0.92 |
| ICPL 84023 | 59 | 131 | 54 | 63 | 4.6 | 11.9 | 0.89 |
| ICPL 151 | 58 | 133 | 44 | 69 | 4.7 | 10.3 | 0.58 |

The test locations were situated at varying latitudes and altitudes. The monthly maximum and minimum temperatures during the growing period differed for each location and sowing dates also varied. The first sowing was done at Ilonga in Dec 1991 and this was followed by Gairu and Nachingirea in February 1992, Ifakara, in March, and Mlingano in April 1992 (**Table 43**).

In view of these environmental factors and varying time of sowing, the growth and productivity varied across locations.

Gairu located at 6° 15' and at the highest altitude of 1094 m, was the most productive location. Sowing at this location was done in Feb 1992. Mean trial yield and the highest yield and the mean harvest index were the highest at this location. Maturity and pod-filling periods were similar to those of the other locations, barring Nachingwea where these parameters were the least. The highest grain yields were produced when the dry matter yields varied between 3.6 and 3.8 t ha-1.

Efforts will be made to study the G x E interactions when data become available from other locations.

At Mlingano, one of the low-yielding environments, 11 cultivars gave over 1 t yield, and ICPL 84023 was the highest yielder. At Gairu, 3 cultivars gave over 3 t $ha^{-1}$ yield, 13 over 2 t and 4 over 1 t $ha^{-1}$. The highest yielder was ICPL 90004 with 3.6 t $ha^{-1}$. Dry matter production at Ifakara was the highest. Grain yields of over 1 t $ha^{-1}$ were recorded by 17 cultivars. At Nachingwea, although the mean plant height was 79 cm, dry matter yield was 1.7 t $ha^{-1}$, but 8 cultivars gave yields exceeding 1 t $ha^{-1}$. All but 3 cultivars gave yields in excess of 1 t $ha^{-1}$ at Ilonga, ICPL 88009 was the highest yielder with 2.13 t $ha^{-1}$ grain.

The relationship of dry matter to grain yield is shown in **Fig. 12**. The coefficients of correlation were low for Mlingano and Ifakara but were statistically significant.

**Table 43. Environmental and production data of pigeonpea trials at five locations (EXPIT DT) in Tanzania.**

| Particulars | Gairu | Ilonga | Ifakara | Mlingano | Nachingwea |
|---|---|---|---|---|---|
| Latitude(°S) | 6°15 | 6°42 | 8°10 | 5° 3 | 10°21 |
| Longitude(°E) | 37°05 | 37°02 | 36°40 | 38°8 | 38°45 |
| Altitude (m) | 1069 | 506 | 270 | 184 | 465 |
| Rainfall (mm) | 177.7 | 1236.6 | 629.2 | 786 2 | 603.1 |
| Sowing date | 14.2.92 | 20.12 91 | 27.3 92 | 10 4 92 | 7.2 92 |
| Harvesting date | 8 6 92 | 23 4.92<br>30 6.92 | 9 7 92 | 17 7 92<br>29 7 92 | 8.5 92 |
| Mean dry matter (t ha$^{-1}$) | 3 8 | 3.6 | 13 9 | 9 3 | 1 7 |
| Mean yield (t ha$^{-1}$) | 2 40 | 1.45 | 1 23 | 1 00 | 0.88 |
| Highest yield (t ha$^{-1}$) | 3.65 | 2.13 | 1 76 | 1 35 | 1.39 |
| Mean harvest index (%) | 63 0 | 40.0 | 8.9 | 10.7 | 51.0 |
| Mean plant height (cm) | 38.6 | 45 1 | 66.5 | 73 8 | 55.6 |
| Highest plant height (cm) | 49 7 | 62 3 | 79.0 | 88.0 | 79.0 |
| Days to maturity | 97.0 | 90 0 | 97 0 | 103 | 80 |
| Days to flowering | 56 0 | 48 | 58 | 55 | 55 |
| Filling period (days) | 41 | 44 | 39 | 48 | 25 |

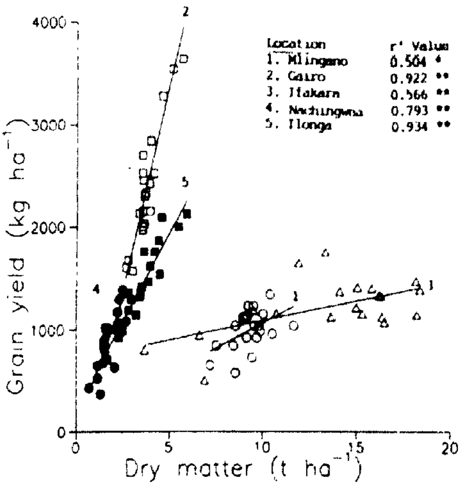


*Figure 12. Relationship of dry matter and grain yield of pigeonpea at five locations in Tanzania, 1991/92.*

Location-wise data are given in **Tables 44-48**.

The extra-short-duration non-determinate pigeonpea trial (EXPIT NDT) consisting of 18 cultivars was conducted at 3 locations. The environmental features of the locations are given in **Table 49**.

Nachingwea and Ilonga were the better producing environments for the non-determinate materials (**Table 50 and 51**). At both locations all but one cultivar gave yields in excess of 1 t $ha^{-1}$. At Ilonga UPAS 120 gave 2.04 t $ha^{-1}$ yield and at Nachingwea it came second to ICPL 88032, both exceeding 2 t $ha^{-1}$ yield. All the cultivars flowered in 50 days earlier than at Ilonga than at Nachngwea and matured at between 96 and 104 days. Plant height was variable among cultivars and was greater at Nachngwea than at Ilonga.

The grain and dry matter yield at Ifakara were less than those at Ilonga. All but 4 cultivars gave yields exceeding 1 t $ha^{-1}$. ICPL 88039 was the highest yielder at Ifakara (**Table 52**).

The relationship of grain yield to dry matter is shown in **Fig. 13**. At all locations, despite differences in maturity and plant height, high and significant correlations were noticed.

**Table 44. Performance of pigeonpea entries in EXPIT 91 DT grown at Gairu, Tanzania, 1992.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | Plant stand | Grain yield (t $ha^{-1}$) | Dry matter yield (t $ha^{-1}$) |
|---|---|---|---|---|---|---|
| ICPL 90004 | 57 | 99 | 36 | 53 | 3.65 | 5.71 |
| ICPL 88017 | 54 | 95 | 32 | 42 | 3.55 | 5.17 |
| ICPL 89024 | 52 | 90 | 35 | 43 | 3.29 | 4.63 |
| ICPL 89027 | 56 | 97 | 38 | 53 | 2.85 | 3.98 |
| ICPL 90011 | 60 | 99 | 36 | 52 | 2.71 | 3.55 |
| ICPL 88015 | 57 | 98 | 39 | 44 | 2.53 | 4.17 |
| ICPL 4 | 60 | 97 | 40 | 48 | 2.53 | 3.55 |
| ICPL 90005 | 52 | 93 | 39 | 39 | 2.46 | 3.86 |
| ICPL 90008 | 56 | 95 | 36 | 52 | 2.43 | 3.92 |
| ICPL 83015 | 57 | 97 | 39 | 44 | 2.34 | 3.70 |
| ICPL 89020 | 54 | 96 | 38 | 44 | 2.31 | 3.64 |
| ICPL 84023 | 58 | 103 | 39 | 55 | 2.16 | 3.94 |
| ICPL 88001 | 55 | 97 | 39 | 44 | 2.16 | 3.55 |
| ICPL 90012 | 56 | 97 | 37 | 57 | 2.14 | 3.38 |
| ICPL 88009 | 61 | 105 | 43 | 45 | 2.04 | 3.64 |
| ICPL 90001 | 62 | 107 | 50 | 43 | 2.01 | 3.55 |
| ICPL 88003 | 55 | 96 | 40 | 42 | 1.97 | 3.55 |
| ICPL 87095 | 53 | 97 | 37 | 49 | 1.67 | 2.77 |
| ICPL 88007 | 52 | 97 | 39 | 47 | 1.61 | 2.65 |
| ICPL 85010 | 54 | 93 | 39 | 51 | 1.57 | 3.01 |
| SE | ±0.8 | ±1.7 | ±3.2 | ±4.4 | ±0.297 | ±0.388 |
| Mean | 56.0 | 97.4 | 38.6 | 47.3 | 2.40 | 3.796 |
| CV (%) | 2.6 | 3.0 | 14.4 | 16.2 | 21.5 | 17.681 |

**Table 45. Performance of pigeonpea entries in EXPIT 91 DT grown at Ilonga, Tanzania, 1991-92.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield ($t\ ha^{-1}$) | Dry matter yield ($t\ ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| ICPL 88009 | 50 | 93 | 62 | 10.3 | 64 | 2.13 | 5.93 |
| ICPL 89027 | 49 | 95 | 45 | 10.3 | 60 | 2.10 | 4.57 |
| ICPL 90001 | 50 | 94 | 59 | 11.3 | 47 | 2.01 | 5.49 |
| ICPL 84023 | 49 | 91 | 52 | 9.7 | 52 | 1.87 | 4.43 |
| ICPL 90008 | 44 | 89 | 44 | 10.3 | 57 | 1.76 | 3.61 |
| ICPL 90011 | 50 | 92 | 50 | 12.3 | 54 | 1.76 | 4.20 |
| ICPL 88001 | 49 | 95 | 49 | 11.7 | 49 | 1.62 | 3.95 |
| ICPL 90004 | 46 | 93 | 48 | 12.3 | 55 | 1.54 | 4.48 |
| ICPL 90012 | 44 | 88 | 43 | 11.0 | 51 | 1.47 | 3.86 |
| ICPL 88003 | 42 | 84 | 45 | 10.0 | 46 | 1.42 | 3.52 |
| ICPL 84023 | 47 | 91 | 46 | 10.3 | 48 | 1.37 | 3.45 |
| ICPL 88007 | 43 | 88 | 44 | 10.7 | 56 | 1.36 | 2.82 |
| ICPL 85010 | 47 | 88 | 40 | 11.0 | 52 | 1.33 | 3.44 |
| ICPL 4 | 49 | 90 | 46 | 8.0 | 56 | 1.30 | 2.98 |
| ICPL 89020 | 43 | 86 | 42 | 10.3 | 52 | 1.19 | 2.81 |
| ICPL 88015 | 49 | 92 | 39 | 9.7 | 53 | 1.14 | 3.23 |
| ICPL 87095 | 43 | 89 | 40 | 10.0 | 53 | 1.00 | 2.21 |
| ICPL 88017 | 43 | 91 | 33 | 9.3 | 38 | 0.99 | 2.49 |
| ICPL 90005 | 43 | 90 | 38 | 10.7 | 49 | 0.93 | 2.31 |
| ICPL 89024 | 42 | 86 | 37 | 9.3 | 50 | 0.71 | 1.71 |
| SE | ±0.9 | ±3.3 | ±2.2 | ±0.59 | ±6.0 | ±0.158 | ±0.341 |
| Mean | 46.1 | 90.3 | 45.1 | 10.43 | 52.2 | 1.45 | 3.574 |
| CV (%) | 3.3 | 6.3 | 8.3 | 9.80 | 19.9 | 18.8 | 16.548 |

**Table 46. Performance of pigeonpea entries in EXPIT 91 DT grown at Ifakara, Tanzania, 1992.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield ($t\ ha^{-1}$) | Dry matter yield ($t\ ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| ICPL 83015 | 58 | 96 | 67 | 8.2 | 65 | 1.76 | 13.35 |
| ICPL 90005 | 58 | 87 | 62 | 9.0 | 64 | 1.65 | 11.93 |
| ICPL 88001 | 59 | 100 | 73 | 10.5 | 69 | 1.48 | 18.18 |
| ICPL 88007 | 55 | 97 | 66 | 10.3 | 68 | 1.42 | 15.08 |
| ICPL 90001 | 62 | 102 | 72 | 11.3 | 58 | 1.41 | 15.85 |
| ICPL 89027 | 59 | 97 | 69 | 11.2 | 71 | 1.40 | 18.40 |
| ICPL 87095 | 50 | 94 | 62 | 9.8 | 60 | 1.38 | 14.14 |
| ICPL 88015 | 59 | 95 | 68 | 8.8 | 62 | 1.34 | 16.22 |
| ICPL 90008 | 57 | 94 | 65 | 9.7 | 62 | 1.34 | 16.33 |

*Continued*

Table 46. *Continued.*

| Genotype | Days to Flowering | Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield (t $ha^{-1}$) | Dry matter yield (t $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| ICPL 90012 | 60 | 103 | 71 | 10.7 | 61 | 1.22 | 15.02 |
| ICPL 88017 | 56 | 95 | 54 | 9.7 | 62 | 1.19 | 9.55 |
| ICPL 89020 | 57 | 97 | 63 | 8.7 | 69 | 1.17 | 10.77 |
| ICPL 88003 | 56 | 96 | 67 | 10.3 | 62 | 1.16 | 15.34 |
| ICPL 85010 | 60 | 99 | 67 | 9.0 | 60 | 1.15 | 18.24 |
| ICPL 90004 | 62 | 102 | 77 | 10.2 | 61 | 1.13 | 16.39 |
| ICPL 90011 | 62 | 98 | 68 | 10.0 | 66 | 1.13 | 13.69 |
| ICPL 88009 | 61 | 98 | 79 | 8.7 | 65 | 1.07 | 16.51 |
| ICPL 4 | 61 | 94 | 67 | 6.3 | 60 | 0.95 | 6.64 |
| ICPL 89024 | 56 | 92 | 56 | 10.0 | 71 | 0.80 | 8.67 |
| ICPL 84023 | 60 | 96 | 56 | 8.5 | 60 | 0.51 | 6.91 |
| SE | ±1.1 | ±2.4 | ±5.0 | ±0.47 | ±4.2 | ±0.262 | ±2.282 |
| Mean | 58.3 | 96.5 | 66.5 | 9.54 | 63.8 | 1.23 | 13.861 |
| CV (%) | 3.4 | 4.2 | 12.9 | 8.54 | 11.3 | 36.9 | 28.512 |

**Table 47. Performance of pigeonpea entries in EXPIT 91 DT grown at Mlingano , Tanzania, 1992.**

| Genotype | Days to Flowering | Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield (t $ha^{-1}$) | Dry matter yield (t $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| ICPL 84023 | 54 | 101 | 71 | 10.7 | 65 | 1.35 | 10.42 |
| ICPL 89027 | 55 | 99 | 72 | 13.0 | 62 | 1.24 | 9.53 |
| ICPL 88007 | 52 | 99 | 66 | 12.3 | 62 | 1.24 | 9.26 |
| ICPL 88015 | 55 | 106 | 77 | 14.0 | 62 | 1.16 | 10.05 |
| ICPL 89020 | 52 | 101 | 71 | 12.0 | 62 | 1.13 | 9.23 |
| ICPL 88001 | 56 | 107 | 79 | 13.3 | 56 | 1.12 | 8.99 |
| ICPL 90001 | 57 | 108 | 78 | 13.7 | 52 | 1.12 | 9.10 |
| ICPL 83015 | 55 | 104 | 73 | 12.7 | 60 | 1.04 | 9.57 |
| ICPL 88009 | 57 | 107 | 88 | 13.0 | 59 | 1.04 | 11.69 |
| ICPL 85010 | 55 | 101 | 80 | 12.7 | 61 | 1.04 | 9.84 |
| ICPL 90008 | 54 | 103 | 72 | 13.0 | 64 | 1.04 | 8.56 |
| ICPL 87095 | 52 | 100 | 64 | 12.0 | 67 | 0.99 | 9.90 |
| ICPL 4 | 57 | 99 | 82 | 10.0 | 68 | 0.97 | 10.53 |
| ICPL 88003 | 54 | 103 | 75 | 13.3 | 63 | 0.93 | 9.16 |
| ICPL 90012 | 54 | 105 | 78 | 13.0 | 61 | 0.93 | 9.70 |
| ICPL 90011 | 57 | 107 | 86 | 14.7 | 65 | 0.85 | 8.45 |
| ICPL 89024 | 52 | 100 | 57 | 11.7 | 65 | 0.85 | 7.54 |
| ICPL 90004 | 56 | 104 | 75 | 14.0 | 61 | 0.73 | 9.45 |
| ICPL 88017 | 53 | 100 | 59 | 12.0 | 59 | 0.66 | 7.21 |
| ICPL 90005 | 52 | 99 | 72 | 13.0 | 64 | 0.58 | 8.55 |
| SE | ±0.5 | ±1.2 | ±4.3 | ±0.41 | ±4.0 | ±0.175 | ±0.614 |
| Mean | 54.5 | 102.6 | 73.8 | 12.70 | 61.9 | 1.00 | 9.337 |
| CV (%) | 1.7 | 2.0 | 10.1 | 5.64 | 11.3 | 30.3 | 11.394 |

**Table 48. Performance of pigeonpea entries in EXPIT 91 DT grown at Nachingwea, Tanzania, 1992.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | Plant stand | Grain yield (t ha⁻¹) | Dry matter yield (t ha⁻¹) |
|---|---|---|---|---|---|---|
| ICPL 88009 | 60 | 83 | 80 | 70 | 1.39 | 2.50 |
| ICPL 88001 | 58 | 90 | 61 | 74 | 1.30 | 2.32 |
| ICPL 90011 | 58 | 80 | 60 | 75 | 1.17 | 2.24 |
| ICPL 90001 | 60 | 96 | 73 | 72 | 1.08 | 2.68 |
| ICPL 85010 | 55 | 74 | 56 | 77 | 1.07 | 2.27 |
| ICPL 84023 | 54 | 74 | 54 | 76 | 1.02 | 1.58 |
| ICPL 89027 | 56 | 81 | 58 | 72 | 1.02 | 1.65 |
| ICPL 90004 | 59 | 78 | 63 | 72 | 1.00 | 1.81 |
| ICPL 88015 | 57 | 79 | 51 | 68 | 1.00 | 1.67 |
| ICPL 90012 | 54 | 78 | 60 | 69 | 0.90 | 1.51 |
| ICPL 89020 | 53 | 82 | 52 | 74 | 0.86 | 1.64 |
| ICPL 88007 | 53 | 82 | 47 | 76 | 0.85 | 1.50 |
| ICPL 90008 | 53 | 84 | 54 | 65 | 0.83 | 1.48 |
| ICPL 4 | 57 | 75 | 59 | 77 | 0.79 | 1.56 |
| ICPL 87095 | 52 | 80 | 56 | 75 | 0.68 | 1.47 |
| ICPL 88003 | 53 | 72 | 47 | 64 | 0.65 | 1.17 |
| ICPL 83015 | 54 | 73 | 53 | 71 | 0.63 | 2.08 |
| ICPL 90005 | 53 | 71 | 46 | 74 | 0.53 | 1.17 |
| ICPL 89024 | 52 | 90 | 40 | 74 | 0.43 | 0.71 |
| ICPL 88017 | 54 | 72 | 43 | 76 | 0.37 | 1.33 |
| SE | ±1.0 | ±5.6 | ±3.8 | ±3.2 | ±0.152 | ±0.388 |
| Mean | 55.2 | 79.8 | 55.6 | 72.4 | 0.88 | 1.712 |
| CV (%) | 3.2 | 12.2 | 11.9 | 7.6 | 30.1 | 39.252 |

**Table 49. Environmental and production data of pigeonpea trials at three locations (EXPIT NDT) in Tanzania.**

| | Nachingwea | Ifakara | Ilonga |
|---|---|---|---|
| Latitude(°S) | 10°21' | 8o10' | 6°42' |
| Longitude(°E) | 38°45' | 36o40' | 37o02' |
| Altitude (m) | 465 | 270 | 506 |
| Rainfall (mm) | 680.8 | 629.2 | 1236.7 |
| Sowing date | 18.2.92 | 27.3.92 | 20.12.91 |
| Harvesting date | 11.6.92 | 10.7.92 | 23.4.92/30.4.92 |
| Mean dry matter (t ha⁻¹) | 2.31 | 3.63 | 4.22 |
| Mean yield (t ha⁻¹) | 1.47 | 1.26 | 1.49 |
| Highest yield (t ha⁻¹) | 2.19 | 1.90 | 2.04 |
| Mean harvest index (%) | 63.4 | 34.7 | 35.3 |
| Mean plant height (cm) | 101 | 81 | 63 |
| Maximum plant height (cm) | 122 | 94 | 80 |
| Days to maturity | 167 | 102 | 99 |
| Days to flowering | 111 | 62 | 47 |
| Filling period (days) | 56 | 40 | 52 |

Table 50. Performance of pigeonpea entries in EXPIT 91 NDT grown at Nachingwea, Tanzania, 1992.

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | Plant stand | Grain yield (t ha⁻¹) | Dry matter yield (t ha⁻¹) |
|---|---|---|---|---|---|---|
| ICPL 88032 | 112 | 169 | 117 | 57 | 2.19 | 3.55 |
| UPAS 120 | 110 | 167 | 122 | 52 | 2.01 | 3.00 |
| ICPL 89008 | 112 | 167 | 104 | 57 | 1.79 | 2.44 |
| ICPL 90031 | 112 | 167 | 109 | 53 | 1.67 | 2.96 |
| ICPL 89011 | 110 | 167 | 98 | 67 | 1.67 | 1.65 |
| ICPL 89001 | 112 | 167 | 109 | 54 | 1.67 | 2.75 |
| ICPL 88039 | 111 | 167 | 101 | 63 | 1.61 | 2.41 |
| ICPL 90030 | 109 | 168 | 98 | 55 | 1.54 | 2.16 |
| ICPL 90033 | 109 | 167 | 112 | 46 | 1.54 | 2.29 |
| ICPL 87111 | 111 | 167 | 96 | 57 | 1.36 | 1.76 |
| ICPL 90039 | 111 | 168 | 97 | 45 | 1.36 | 2.28 |
| ICPL 90038 | 110 | 167 | 106 | 46 | 1.30 | 2.78 |
| ICPL 90032 | 111 | 167 | 96 | 57 | 1.27 | 2.44 |
| ICPL 90036 | 110 | 168 | 120 | 37 | 1.24 | 2.37 |
| ICPL 89004 | 112 | 167 | 86 | 41 | 1.20 | 1.88 |
| ICPL 89012 | 111 | 167 | 91 | 52 | 1.08 | 2.01 |
| ICPL 90035 | 110 | 167 | 89 | 54 | 1.05 | 1.67 |
| ICPL 4 | 109 | 167 | 72 | 54 | 0.86 | 1.20 |
| SE | ±1.6 | ±0.5 | ±10.2 | ±4.7 | ±0.246 | ±0.455 |
| Mean | 110.7 | 167.3 | 101.3 | 52.6 | 1.47 | 2.311 |
| CV (%) | 2.5 | 0.5 | 17.4 | 15.4 | 29.0 | 34.076 |

Table 51. Performance of pigeonpea entries in EXPIT 91 NDT grown at Ilonga, Tanzania, 1991-92.

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield (t ha⁻¹) | Dry matter yield (t ha⁻¹) |
|---|---|---|---|---|---|---|---|
| UPAS 120 | 51 | 104 | 72 | 9.3 | 55 | 2.04 | 5.54 |
| ICPL 89008 | 50 | 98 | 80 | 10.3 | 65 | 1.93 | 5.71 |
| ICPL 90039 | 48 | 99 | 62 | 10.3 | 55 | 1.75 | 4.46 |
| ICPL 87111 | 48 | 98 | 71 | 10.3 | 60 | 1.73 | 4.37 |
| CPL 88039 | 44 | 96 | 58 | 11.3 | 54 | 1.70 | 4.79 |
| CPL 88032 | 49 | 98 | 60 | 10.7 | 51 | 1.62 | 3.78 |
| CPL 90035 | 43 | 101 | 52 | 10.0 | 53 | 1.61 | 5.00 |
| ICPL 89001 | 51 | 98 | 72 | 10.3 | 59 | 1.57 | 4.80 |
| ICPL 90036 | 50 | 98 | 72 | 11.0 | 47 | 1.54 | 4.32 |
| ICPL 90038 | 44 | 99 | 59 | 10.0 | 59 | 1.44 | 4.29 |
| CPL 89012 | 44 | 102 | 52 | 10.0 | 51 | 1.34 | 3.11 |
| ICPL 90033 | 46 | 100 | 58 | 11.3 | 58 | 1.31 | 3.75 |
| ICPL 90032 | 47 | 100 | 77 | 11.0 | 43 | 1.30 | 4.40 |
| ICPL 89011 | 51 | 100 | 56 | 10.3 | 59 | 1.27 | 3.91 |
| CPL 90031 | 49 | 98 | 65 | 11.0 | 43 | 1.27 | 3.75 |
| 'CPL 89004 | 44 | 99 | 61 | 9.7 | 55 | 1.24 | 3.02 |
| ICPL 90030 | 44 | 99 | 57 | 11.0 | 53 | 1.23 | 4.18 |
| ICPL 4 | 50 | 96 | 43 | 7.3 | 47 | 0.93 | 2.76 |
| SE | ±0.9 | ±2.4 | ±4.6 | ±0.45 | ±5.2 | ±0.138 | ±0.478 |
| Mean | 47.4 | 99.2 | 62.5 | 10.30 | 53.7 | 1.49 | 4.219 |
| CV (%) | 3.2 | 4.1 | 12.8 | 7.57 | 16.8 | 16.0 | 19.626 |

**Table 52. Performance of pigeonpea entries in EXPIT 91 NDT grown at Ifakara, Tanzania, 1992.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield (t ha⁻¹) | Dry matter yield (t ha⁻¹) |
|---|---|---|---|---|---|---|---|
| ICPL 88039 | 61 | 103 | 85 | 10.7 | 64 | 1.90 | 5.08 |
| ICPL 90039 | 61 | 104 | 90 | 9.3 | 61 | 1.74 | 4.72 |
| ICPL 90032 | 62 | 101 | 92 | 10.3 | 64 | 1.63 | 4.80 |
| ICPL 89008 | 63 | 104 | 85 | 9.0 | 54 | 1.61 | 3.69 |
| ICPL 89011 | 63 | 100 | 83 | 8.7 | 70 | 1.57 | 3.44 |
| ICPL 90031 | 64 | 104 | 83 | 9.0 | 60 | 1.37 | 4.35 |
| ICPL 90036 | 63 | 102 | 75 | 10.3 | 46 | 1.34 | 3.91 |
| UPAS 120 | 61 | 103 | 76 | 7.7 | 64 | 1.27 | 3.10 |
| ICPL 90038 | 61 | 101 | 94 | 9.7 | 66 | 1.23 | 3.78 |
| ICPL 87111 | 58 | 98 | 81 | 9.0 | 63 | 1.17 | 3.55 |
| ICPL 90030 | 61 | 103 | 74 | 9.3 | 61 | 1.17 | 3.53 |
| ICPL 89004 | 63 | 102 | 83 | 9.0 | 67 | 1.17 | 4.14 |
| ICPL 88032 | 63 | 98 | 78 | 9.7 | 59 | 1.10 | 3.70 |
| ICPL 4 | 61 | 97 | 76 | 7.0 | 47 | 1.00 | 2.53 |
| ICPL 90033 | 64 | 104 | 83 | 10.3 | 62 | 0.90 | 3.44 |
| ICPL 90035 | 58 | 99 | 74 | 9.0 | 51 | 0.86 | 2.47 |
| ICPL 89001 | 63 | 104 | 72 | 8.7 | 60 | 0.82 | 2.22 |
| ICPL 89012 | 61 | 104 | 66 | 9.0 | 56 | 0.80 | 2.81 |
| SE | ±0.8 | ±1.0 | ±9.1 | ±0.68 | ±6.1 | ±0.242 | ±0.454 |
| Mean | 61.8 | 101.7 | 80.5 | 9.20 | 59.7 | 1.26 | 3.625 |
| CV (%) | 2.3 | 1.8 | 19.6 | 12.72 | 17.6 | 33.3 | 21.700 |

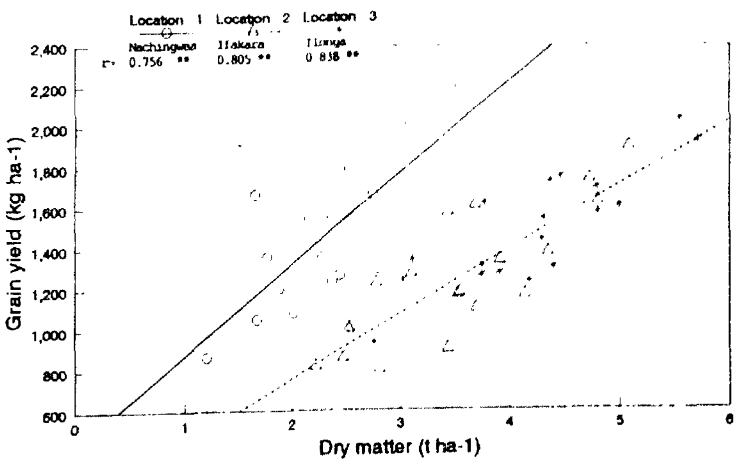


*Figure 13. Relationship of dry matter and grain yield of pigeonpea at three locations in Tanzania, 1991/92.*

**The short-duration non-determinate pigeonpea trial (EPIT NDT) was conducted at 3 locations.** Eighteen cultivars of short-duration were tested at Ilonga, Mlingano and Nalienaele during the crop season of 1991/1992. The environmental features of these locations are given in **Table 53**. The mean dry matter yields were high at Nalienaele and at Mlingano but the correlations between dry matter and grain yield was statistically non-significant for both locations being positive in the case of Mlingano and negative for Nalienaele (**Fig. 14**).

In Mlingano all the cultivars gave yields in excess of 1 ton (**Table 54**) and the highest yielder was ICPL 86023. The highest yielding line at Nalienaele was ICPL 88034 with 3.51 t $ha^{-1}$ (**Table 55**). At this location all but 1 cultivar gave over 1 ton grain yield.

The dry matter yield at Ilonga was approximately half that of the other 2 locations (**Table 56**). The coefficients of correlation between days to maturity and yield was significant ($r^2$ = .9138). ICPL 90050 and ICPL 89007 gave over 2 t ha-1 yield. Thirteen others gave over 1 t ha-1 yield (**Table 56**).

**Table 53. Environmental and production data of pigeonpea trials at three locations (EPIT NDT) in Tanzania.**

| | Ilonga | Mlingano | Nalienaele |
|---|---|---|---|
| Latitude(°S) | 6°42' | 5°03' | 10°22' |
| Longitude(°E) | 37°02' | 38°8' | 40°10' |
| Altitude (m) | 506 | 184 | 120 |
| Rainfall (mm) | 1236.7 | 786.2 | 1413 |
| Sowing date | 3.3.92 | 13.4.92 | 20.2.92 |
| Harvesting date | 10.7.92 | 30.8.92 | 22.6.92 |
| Mean dry matter (t $ha^{-1}$) | 5.79 | 11.08 | 9.22 |
| Mean yield (t $ha^{-1}$) | 1.51 | 2.04 | 1.71 |
| Highest yield (t $ha^{-1}$) | 2.90 | 2.89 | 3.51 |
| Mean harvest index (%) | 26.2 | 18.4 | 18.5 |
| Mean plant height (cm) | 108 | 156 | 180 |
| Highest plant height (cm) | 140 | 178 | 221 |
| Days to maturity | 108 | 126 | 111 |
| Days to flowering | 57 | 61 | 72 |
| Filling period (days) | 51 | 65 | 39 |

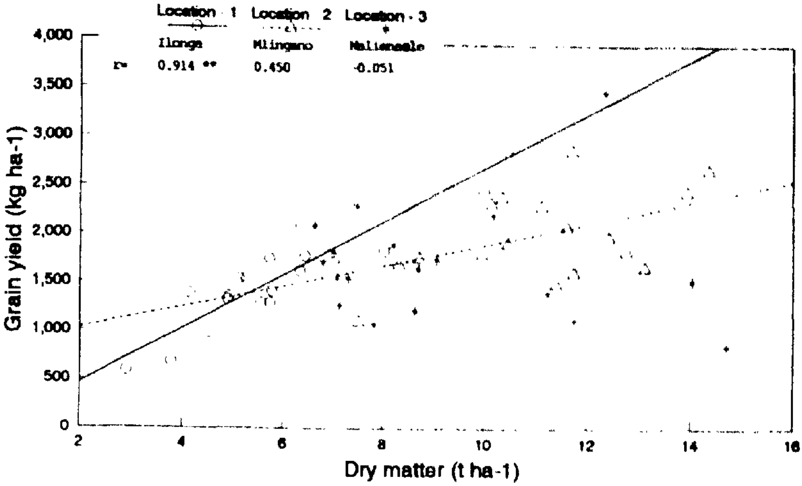


*Figure 14. Relationship of dry matter and grain yield of pigeonpea at three locations in Tanzania, 1991/92*

**Table 54. Performance of pigeonpea entries in EPIT 91 NDT grown at Mlingano, Tanzania, 1992.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield (t ha⁻¹) | Dry matter yield (t ha⁻¹) |
|---|---|---|---|---|---|---|---|
| ICPL 86023 | 59 | 129 | 136 | 16.0 | 61 | 2.89 | 11.69 |
| ICPL 85045 | 66 | 137 | 174 | 13.0 | 58 | 2.70 | 14.35 |
| ICPL 90052 | 58 | 113 | 132 | 12.3 | 47 | 2.50 | 9.99 |
| ICPL 88034 | 65 | 134 | 173 | 13.3 | 59 | 2.47 | 13.93 |
| ICPL 90046 | 63 | 130 | 151 | 12.3 | 54 | 2.41 | 10.35 |
| ICPL 87115 | 61 | 137 | 170 | 11.3 | 53 | 2.35 | 10.14 |
| ICPL 90053 | 60 | 118 | 167 | 12.3 | 52 | 2.32 | 11.11 |
| ICPL 90048 | 59 | 127 | 155 | 13.7 | 47 | 2.10 | 11.59 |
| ICPL 86015 | 61 | 128 | 170 | 11.3 | 58 | 1.99 | 12.40 |
| ICPL 89007 | 61 | 137 | 152 | 16.7 | 57 | 1.93 | 10.46 |
| ICPL 90054 | 66 | 134 | 181 | 15.0 | 48 | 1.85 | 12.73 |
| ICPL 87114 | 58 | 113 | 148 | 13.0 | 59 | 1.81 | 9.95 |
| ICPL 90044 | 58 | 120 | 145 | 12.3 | 53 | 1.78 | 8.72 |
| ICPL 90045 | 58 | 118 | 142 | 12.7 | 48 | 1.71 | 8.31 |
| ICPL 90043 | 59 | 120 | 149 | 13.0 | 60 | 1.68 | 13.10 |
| ICPL 90050 | 59 | 122 | 149 | 12.0 | 52 | 1.62 | 11.73 |
| ICPL 89018 | 60 | 128 | 178 | 13.3 | 51 | 1.51 | 11.38 |
| UPAS 120 | 61 | 120 | 143 | 10.7 | 50 | 1.10 | 7.51 |
| SE | ±0.6 | ±2.5 | ±8.1 | ±0.47 | ±5.0 | ±0.439 | ±1.456 |
| Mean | 60.6 | 125.8 | 156.4 | 13.02 | 53.7 | 2.04 | 11.079 |
| CV (%) | 1.7 | 3.5 | 9.0 | 6.27 | 16.1 | 37.3 | 22.769 |

**Table 55. Performance of pigeonpea entries in EPIT 91 NDT grown at Nalienaele, Tanzania, 1992.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield (t ha⁻¹) | Dry matter yield (t ha⁻¹) |
|---|---|---|---|---|---|---|---|
| ICPL 88034 | 73 | 113 | 197 | 11.3 | 66 | 3.51 | 12.32 |
| ICPL 89007 | 73 | 120 | 200 | 14.3 | 67 | 2.31 | 7.48 |
| ICPL 87115 | 72 | 110 | 196 | 10.0 | 55 | 2.23 | 10.17 |
| ICPL 90043 | 71 | 103 | 164 | 10.7 | 65 | 2.11 | 6.62 |
| ICPL 90050 | 70 | 106 | 165 | 10.3 | 56 | 1.91 | 8.21 |
| ICPL 87114 | 70 | 104 | 171 | 11.0 | 61 | 1.83 | 7.00 |
| ICPL 90048 | 72 | 108 | 146 | 11.7 | 61 | 1.76 | 9.06 |
| UPAS 120 | 68 | 105 | 172 | 9.3 | 58 | 1.72 | 6.80 |
| ICPL 86015 | 72 | 110 | 194 | 10.7 | 73 | 1.66 | 8.72 |
| ICPL 90053 | 72 | 108 | 181 | 10.3 | 54 | 1.56 | 7.08 |
| ICPL 90052 | 69 | 103 | 105 | 11.0 | 62 | 1.56 | 7.29 |
| ICPL 85045 | 73 | 117 | 217 | 11.3 | 64 | 1.54 | 14.03 |
| ICPL 90046 | 77 | 125 | 214 | 11.7 | 56 | 1.41 | 11.22 |
| ICPL 86023 | 71 | 105 | 140 | 12.7 | 57 | 1.28 | 7.13 |
| ICPL 90044 | 71 | 109 | 183 | 11.7 | 71 | 1.23 | 8.64 |
| ICPL 89018 | 71 | 110 | 195 | 10.0 | 71 | 1.13 | 11.73 |
| ICPL 90045 | 71 | 112 | 181 | 11.0 | 70 | 1.08 | 7.82 |
| ICPL 90054 | 78 | 121 | 221 | 12.0 | 68 | 0.86 | 14.70 |
| SE | ±1.0 | ±2.2 | ±12.4 | ±0.43 | ±4.8 | ±0.341 | ±0.937 |
| Mean | 71.9 | 110.4 | 180.0 | 11.17 | 63.0 | 1.71 | 9.223 |
| CV (%) | 2.5 | 3.4 | 12.0 | 6.69 | 13.1 | 34.6 | 17.594 |

**Table 56. Performance of pigeonpea entries in EPIT 91 NDT grown at Ilonga, Tanzania, 1992.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield (t ha⁻¹) | Dry matter yield (t ha⁻¹) |
|---|---|---|---|---|---|---|---|
| ICPL 90050 | 56 | 108 | 128 | 11.3 | 51 | 2.90 | 10.43 |
| ICPL 89007 | 58 | 118 | 117 | 13.7 | 43 | 2.10 | 6.34 |
| ICPL 90054 | 61 | 116 | 140 | 14.0 | 54 | 1.85 | 8.02 |
| ICPL 90044 | 57 | 100 | 115 | 11.0 | 45 | 1.79 | 6.43 |
| ICPL 86023 | 56 | 105 | 111 | 12.0 | 44 | 1.76 | 5.72 |
| ICPL 86015 | 56 | 106 | 119 | 11.3 | 36 | 1.73 | 7.01 |
| ICPL 90043 | 56 | 106 | 117 | 11.7 | 45 | 1.64 | 6.33 |
| ICPL 90052 | 55 | 97 | 68 | 11.3 | 38 | 1.54 | 5.25 |
| ICPL 90046 | 59 | 111 | 118 | 12.7 | 36 | 1.54 | 6.11 |
| ICPL 87115 | 58 | 112 | 105 | 12.0 | 38 | 1.42 | 5.76 |
| ICPL 90045 | 53 | 100 | 94 | 10.7 | 40 | 1.39 | 4.14 |
| CPL 87114 | 55 | 98 | 103 | 11.3 | 36 | 1.36 | 4.92 |
| ICPL 85045 | 60 | 113 | 100 | 11.7 | 46 | 1.33 | 4.89 |
| ICPL 90048 | 56 | 108 | 109 | 12.7 | 36 | 1.30 | 5.73 |
| ICPL 90053 | 56 | 110 | 100 | 11.3 | 44 | 1.30 | 5.55 |
| UPAS 120 | 56 | 108 | 99 | 12.7 | 46 | 0.99 | 4.52 |
| ICPL 88034 | 60 | 112 | 103 | 12.0 | 29 | 0.68 | 3.77 |
| ICPL 89018 | 58 | 114 | 95 | 12.0 | 36 | 0.59 | 2.90 |
| SE | ±0.6 | ±2.2 | ±9.7 | ±0.82 | ±5.7 | ±0.268 | ±0.788 |
| Mean | 57.0 | 107.8 | 107.9 | 11.96 | 41.2 | 1.51 | 5.768 |
| CV (%) | 1.9 | 3.5 | 15.6 | 11.85 | 23.9 | 30.7 | 23.661 |

**Panama**

Data from two experiments consisting of extra-short (EXPIT 90 DT) and short-duration (EPIT 90 DT) cultivars conducted in the 1990/91 cropping season in Panama are given in **Table 57 and 58**.

**Table 57** shows the grain yield, flowering and maturity duration, plant height and other characters of 18 extra-short-duration cultivars. Flowering and crop durations were similar to IC even though latitude and altitude of the test locations differed. ICPLs 89022, ICPL 85014, and 88001 yielded respectively 2.41, 2.37 and 2.00 t $ha^{-1}$. The yields of 4 other cultivars ICPLs 89026, 83015, 84023, 85030 were close to 2 t $ha^{-1}$.

The mean yield of short-duration cultivars (**Table 58**) was 1.40 t $ha^{-1}$, with the highest yield of 1.84 t $ha^{-1}$ recorded by ICPL 88018. The short-duration cultivars in general were less productive than the extra-short-duration cultivars, however in terms of crop duration and plant height the two groups did not differ very significantly.

**Table 57. Performance of pigeonpea entries in EXPIT 90 DT grown in Panama, 1992.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield (t $ha^{-1}$) |
|---|---|---|---|---|---|---|
| ICPL 89022 | 58 | 92 | 97 | 8.0 | 73 | 2.41 |
| ICPL 85014 | 65 | 99 | 112 | 9.4 | 63 | 2.37 |
| ICPL 88001 | 62 | 99 | 88 | 11.2 | 67 | 2.00 |
| ICPL 89026 | 63 | 99 | 101 | 9.7 | 60 | 2.00 |
| ICPL 83015 | 62 | 94 | 97 | 9.1 | 67 | 1.98 |
| ICPL 84023 | 57 | 87 | 81 | 7.8 | 57 | 1.96 |
| ICPL 85030 | 62 | 101 | 81 | 11.2 | 50 | 1.92 |
| ICPL 89025 | 58 | 91 | 86 | 11.0 | 63 | 1.90 |
| ICPL 83006 | 63 | 95 | 103 | 8.2 | 60 | 1.85 |
| ICPL 4 (C) | 63 | 92 | 106 | 6.7 | 70 | 1.78 |
| ICPL 89024 | 55 | 83 | 71 | 8.9 | 80 | 1.74 |
| ICPL 89020 | 57 | 89 | 84 | 9.4 | 50 | 1.69 |
| ICPL 88015 | 66 | 100 | 91 | 10.1 | 60 | 1.58 |
| ICPL 88007 | 56 | 87 | 77 | 9.4 | 70 | 1.46 |
| ICPL 88017 | 55 | 85 | 71 | 10.7 | 60 | 1.39 |
| ICPL 89021 | 56 | 88 | 79 | 9.6 | 50 | 1.37 |
| ICPL 85024 | 54 | 83 | 68 | 8.9 | 77 | 1.36 |
| ICPL 87095 | 55 | 84 | 73 | 8.2 | 73 | 1.33 |
| SE | ±0.8 | ±1.1 | ±3.0 | ±0.02 | ±4.0 | ±0.198 |
| Mean | 59.2 | 91.5 | 87.2 | 9.30 | 63.9 | 1.78 |
| CV (%) | 2.2 | 2.1 | 6.0 | 0.38 | 10.9 | 19.3 |

**Table 58. Performance of pigeonpea entries in EPIT 90 DT grown in Panama, 1990-91.**

| Genotype | Days to Flowering | Days to Maturity | Plant height (cm) | 100-seed mass (g) | Plant stand | Grain yield ($t\ ha^{-1}$) |
|---|---|---|---|---|---|---|
| ICPL 88018 | 70 | 105 | 103 | 11.1 | 60 | 1.84 |
| ICPL 84031 | 68 | 105 | 93 | 9.3 | 48 | 1.67 |
| ICPL 89031 | 65 | 103 | 85 | 12 3 | 67 | 1.63 |
| ICPL 87102 | 66 | 102 | 83 | 11.7 | 55 | 1.61 |
| ICPL 88027 | 71 | 109 | 103 | 10.5 | 47 | 1.56 |
| ICPL 86005 | 67 | 102 | 95 | 13.5 | 47 | 1.55 |
| ICPL 87 | 73 | 113 | 98 | 10.7 | 48 | 1 49 |
| ICPL 87105 | 66 | 106 | 100 | 11.3 | 50 | 1 49 |
| ICPL 89030 | 72 | 107 | 96 | 10.4 | 40 | 1.48 |
| ICPL 87104 | 67 | 105 | 93 | 12.1 | 45 | 1.41 |
| ICPL 87109 | 71 | 105 | 108 | 13.4 | 43 | 1 36 |
| ICPL 87108 | 73 | 109 | 98 | 16.7 | 43 | 1.33 |
| ICPL 88025 | 65 | 104 | 83 | 14.2 | 42 | 1.33 |
| ICPL 151 | 68 | 103 | 95 | 12.0 | 30 | 1.28 |
| ICPL 88023 | 68 | 106 | 92 | 13.0 | 57 | 1.27 |
| ICPL 86012 | 68 | 104 | 97 | 10.5 | 35 | 1 16 |
| ICPL 87101 | 68 | 104 | 100 | 12.6 | 47 | 1.15 |
| ICPL 89032 | 62 | 97 | 81 | 8.4 | 50 | 1.14 |
| ICPL 86013 | 72 | 108 | 117 | 10.5 | 43 | 1.12 |
| ICPL 88026 | 74 | 108 | 105 | 11.1 | 28 | 1.11 |
| SE | ±0.9 | ±1.0 | ±2.9 | ±0.05 | ±7.9 | ±0.205 |
| Mean | 68.6 | 105.2 | 96.4 | 11.77 | 46.3 | 1.40 |
| CV (%) | 2.2 | 1.7 | 5.1 | 0.67 | 29.7 | 25.4 |

**Philippines**

The Institute of Plant Breeding, University of the Philippines has embarked on seed production of selected pigeonpea lines. Two among them are derivatives of ICPL 295, a wilt-resistant, salinity-tolerant, medium-duration line made available during the 1985 variety testing program.

The derived lines have been renamed Brooks 1 (295-1-1-2-1) and Saludar (295-4-7-1) seed multiplication and distribution to farmers is in progress.

Pigeonpea is not a major legumes in the Philippines. Certain pockets of Isabela, Batanga, Qreeyon, and Cagayan grow the crop for human consumption and as a live stock feed. It is often cultivated as a backyard or field boundary crop. A few farmers grow small plots of sole crop pigeonpea.

**Nepal**

The study tour to monitor AGLOR trials was conducted during 8 to 12 Feb 1993 in Nepal.

The team visited four locations in Sarlahi, five in Bardia, and four in Banke district. In the improved package of practices the team observed excellent plant stand, good growth, and profuse flowering. No wilt, sterility mosaic or stem canker was observed with the improved package. At some locations the varieties used in the 'local' package of practices were susceptible to wilt.

In a Farmers' Field Trial (FFT) at Khairapur village in Bardia district, two wilt and sterility mosaic resistant lines (ICPL 87133 and ICPL 84032) were compared with Bageshwari, and a local variety. Both appeared superior to Bageshwari and the local variety. These may be included as additional entries in the 1993/94 on-farm trials.

One of the cultivars grown by farmers of Banke and Bardia Districts resembles ICPL 366 morphologically, and we have requested the Agriculture Development Officer, Bardia District and the Coordinator of the National Grain Legumes Research Program (NGLRP) to ascertain the origin of that cultivar. Our initial assessment is that the cultivar is ICPL 366 and it could have spread through Farmers Field Trials conducted by NGLRP. There is a need to verify this. If it turns out to be ICPL 366, it would be another instance of successful impact of our improved germplasm.

K.C. Jain evaluated on-station trials at Nepalganj and Nawalpur. At Nepalganj, long-duration CVT and IET materials were at the flowering stage. Generally good plant stand and growth was observed in many entries. However, one replication each in MPIT and LPIT had poor plant stand due to waterlogging. At Nawalpur, CVT, IET, Farmers Field Trial, and Method of Sowing and Spacing Trials were adversely affected by waterlogging during early growth and by moisture stress at the flowering stage.

**Performance of extra-short-duration lines in multilocational trials in India**

Twenty extra-short-duration determinate lines were made available for multilocation testing in India during the 1992 rainy season. Yield data are available from seven locations for analysis. Among the lines tested ICPLs 88009 and 88007 were found promising (**Table 59**). These two lines recorded high yields of 1.90 t $ha^{-1}$ and 2.0 t $ha^{-1}$ at Modipuram.

**Table 59. Yield (kg $ha^{-1}$) performance of extra-short-duration DT pigeonpea lines in multilocational trials in India, rainy season 1992.**

| | Patancheru | | | | | Diphu | | | |
|---|---|---|---|---|---|---|---|---|---|
| ICPL No | Alfisol 1 | Vertisol 1 | Alfisol 2 | Vertisol 2 | Modipuram | (Assam) | Rahuri | SK Nagar | Mean |
| ICPL 83015 | 1329(10)[1] | 1281(13) | 1110(5) | 853(2) | 1512(15) | 868(7) | 587(14) | 625(9) | 1077 |
| ICPL 84023 | 1224(13) | 1443(8) | 877(11) | 567(13) | 1404(16) | 662(8) | 857(8) | 733(8) | 1005 |
| ICPL 85010 | 1668(1) | 1370(11) | 1071(7) | 543(15) | 1952(7) | 928(3) | 1065(4) | 972(3) | 1228 |
| ICPL 87095 | 1435(7) | 1271(14) | 815(15) | 670(6) | 2222(1) | 978(2) | 1165(3) | 393(18) | 1222 |
| ICPL 88001 | 1336(9) | 1528(4) | 1095(6) | 687(5) | 2137(2) | 485(11) | 556(15) | 810(6) | 1118 |
| ICPL 88003 | 1113(16) | 1048(18) | 914(10) | 433(20) | 1381(18) | 537(9) | 432(18) | 463(15) | 837 |
| ICPL 88007 | 1443(6) | 1432(9) | 969(9) | 553(14) | 2022(4) | 1422(1) | 1204(2) | 254(20) | 1292 |
| ICPL 88009 | 1662(2) | 1536(3) | 1053(8) | 1090(1) | 1898(8) | 892(6) | 1011(6) | 849(5) | 1306 |
| ICPL 88015 | 1025(17) | 864(20) | 836(13) | 653(8) | 1738(11) | 493(10) | 432(17) | 540(13) | 863 |
| ICPL 88017 | 704(20) | 1220(15) | 1340(1) | 530(17) | 1983(5) | 355(14) | 386(20) | 594(10) | 931 |
| ICPL 89020 | 1409(8) | 1471(7) | 777(18) | 827(3) | 1289(19) | 236(17) | 741(10) | 432(17) | 964 |
| ICPL 89024 | 822(19) | 1118(16) | 492(19) | 537(16) | 1983(6) | 926(4) | 648(11) | 385(19) | 932 |
| ICPL 89027 | 1150(15) | 1779(1) | 805(16) | 627(10) | 1659(13) | 249(16) | 787(9) | 579(11) | 1008 |
| ICPL 90001 | 1531(4) | 1492(5) | 876(12) | 670(7) | 1589(14) | 257(15) | 1035(5) | 532(14) | 1064 |
| ICPL 90004 | 1011(18) | 1185(17) | 1145(4) | 520(18) | 1806(16) | 235(18) | 617(13) | 1119(2) | 931 |
| ICPL 90005 | 1245(12) | 947(19) | 446(20) | 573(12) | 1105(20) | 123(20) | 409(19) | 455(16) | 693 |
| ICPL 90008 | 1531(3) | 1349(12) | 819(14) | 757(4) | 1690(12) | 451(12) | 918(7) | 887(4) | 1074 |
| ICPL 90011 | 1454(5) | 1387(10) | 1203(2) | 513(19) | 1890(9) | 399(13) | 1250(1) | 741(7) | 1157 |
| ICPL 90012 | 1167(14) | 1639(2) | 1145(3) | 643(9) | 2106(3) | 123(19) | 625(12) | 1412(1) | 1064 |
| Control | | | | | | | | | |
| ICPL 4 | 1315(11) | 1486(6) | 797(17) | 603(11) | 1404(17) | 915(5) | 463(16) | 571(12) | 998 |
| SE | ±196.3 | ±198.9 | ±78.2 | ±87.2 | ±177.1 | ±72.0 | ±33.6 | ±169.9 | |
| Mean | 1280.1 | 1345.9 | 929.2 | 642.5 | 1738.5 | 576.5 | 759.3 | 667.4 | |
| CV (%) | 26.6 | 25.6 | 14.6 | 23.5 | 17.6 | 21.6 | 7.7 | 44.1 | |

1. Figures in parentheses indicate ranks.

Among extra-short-duration indeterminate lines, ICPL 89008 and ICPL 88039 were found promising (**Table 60**).

### Performance of short-duration lines in multilocation trials in India

Eighteen short-duration indeterminate lines were provided for multilocational trials in India during the 1992 rainy season. The results from seven locations are available for analysis. The yield data indicated that ICPLs 89018, 87115 and 86015 were promising (**Table 61**). The line ICPL 89018 recorded the highest yield (3.89 t $ha^{-1}$) at Pal, Jalgaon and was among the top three entries at 4 out of seven locations.

**Table 60. Yield (kg $ha^{-1}$) performance of extra-short-duration NDT pigeonpea lines in multilocational trials in India, rainy season 1992.**

| | Patancheru | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ICPL No | Alfisol | Vertisol | Expt block | Modipuram | Diphu (Assam) | SK Nagar | Akola | Mean |
| ICPL 87111 | 971(4)[1] | 1446(1) | 485(6) | 1059(15) | 1500(1) | 1173(7) | 848(3) | 1133 |
| ICPL 88032 | 804(12) | 1049(10) | 267(17) | 1770(3) | 812(12) | 1458(4) | 478(8) | 1062 |
| ICPL 88039 | 1114(1) | 1195(6) | 661(1) | 1596(4) | 1465(2) | 1451(5) | 432(13) | 1209 |
| ICPL 89001 | 641(16) | 1133(9) | 539(3) | 1209(14) | 853(10) | 841(18) | 633(4) | 885 |
| ICPL 89004 | 607(18) | 830(17) | 395(10) | 1012(17) | 710(14) | 856(17) | 324(17) | 723 |
| ICPL 89008 | 1036(2) | 1406(2) | 541(2) | 2440(1) | 1067(4) | 995(13) | 772(1) | 1286 |
| ICPL 89011 | 853(9) | 858(16) | 307(14) | 1378(9) | 1013(6) | 1057(11) | 355(16) | 918 |
| ICPL 89012 | 617(17) | 965(12) | 161(18) | 1347(11) | 634(15) | 1127(9) | 393(15) | 847 |
| ICPL 90030 | 807(11) | 1040(11) | 422(8) | 1304(13) | 814(11) | 880(16) | 548(6) | 899 |
| ICPL 90031 | 702(15) | 918(13) | 304(15) | 1429(8) | 1307(3) | 911(15) | 741(2) | 1001 |
| ICPL 90032 | 954(6) | 1162(7) | 348(12) | 1588(5) | 776(13) | 1134(8) | 479(7) | 1015 |
| ICPL 90033 | 940(8) | 872(15) | 504(5) | 1818(2) | 598(16) | 1350(6) | 463(9) | 1007 |
| ICPL 90035 | 875(7) | 892(14) | 289(16) | 1355(10) | 873(9) | 1042(12) | 432(12) | 912 |
| ICPL 90036 | 852(10) | 699(18) | 433(7) | 1019(16) | 482(18) | 1481(3) | 448(11) | 830 |
| ICPL 90038 | 764(13) | 1259(5) | 388(11) | 1571(6) | 501(17) | 965(14) | 455(10) | 919 |
| ICPL 90039 | 867(8) | 1301(4) | 505(4) | 1324(12) | 905(8) | 1080(10) | 277(18) | 859 |
| Controls | | | | | | | | |
| UPAS 120 | 970(3) | 1326(3) | 399(9) | 1451(7) | 964(7) | 1628(1) | 393(14) | 1122 |
| ICPL 4 (C) | 725(14) | 1133(8) | 386(12) | 857(18) | 1026(5) | 1574(2) | 555(5) | 978 |
| SE | ±95.1 | +186 6 | ±84.8 | ±237.7 | ±42.6 | ±146.0 | ± 38.2 | |
| Mean | 838 8 | 1082 4 | 407.5 | 1417.9 | 905.6 | 1166.8 | 490.4 | |
| CV (%) | 19.6 | 29.9 | 36.1 | 29.0 | 8.1 | 21.7 | 13.5 | |

1 Values in brackets indicate the rank

**Table 61. Yield (kg $ha^{-1}$) performance of short-duration NDT lines in multilocation trials, rainy season 1992.**

| ICPL No. | Patancheru Alfisol | Patancheru Vertisol | Modipuram | Lam | Pantnagar | Rahuri | Jalgaon | SK Nagar | Akola | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| ICPL 85045 | 1318(5)[1] | 628(15) | 1103(11) | 764(12) | 2824(11) | 818(6) | 3736(3) | 1134(5) | 366(11) | 1587 |
| ICPL 86015 | 1261(7) | 980(6) | 927(16) | 1129(5) | 3395(3) | 718(12) | 3380(4) | 1042(8) | 517(5) | 1635 |
| ICPL 86023 | 963(18) | 1215(4) | 1249(7) | 824(10) | 3256(5) | 1042(3) | 2307(17) | 733(18) | 370(10) | 1358 |
| ICPL 87114 | 983(17) | 614(16) | 917(17) | 571(16) | 3503(1) | 432(18) | 3226(6) | 784(16) | 571(2) | 1436 |
| ICPL 87115 | 1578(1) | 1481(3) | 1874(1) | 1376(2) | 3287(4) | 833(5) | 2809(13) | 1227(1) | 633(1) | 1678 |
| ICPL 88034 | 1546(2) | 444(17) | 1398(5) | 1550(1) | 3009(8) | 440(17) | 3163(9 | 1142(4) | 483(6) | 1616 |
| ICPL 89007 | 1187(12) | 673(13) | 1154(9) | 982(7) | 2068(18) | 509(16) | 2146(18) | 926(12) | 282(14) | 1154 |
| ICPL 89018 | 1205(11) | 1492(2) | 1046(13) | 1148(3) | 3426(2) | 1096(1) | 3896(2) | 880(14) | 455(7) | 1729 |
| ICPL 90043 | 1363(4) | 858(9) | 1583(3) | 725(14) | 3086(7) | 795(7) | 3133(11) | 880(14) | 401(8) | 1483 |
| ICPL 90044 | 1224(9) | 734(11) | 957(15) | 975(8) | 3164(6) | 764(10) | 3001(12) | 1181(2) | 525(3.5) | 1548 |
| ICPL 90045 | 1216(10) | 630(14) | 1517(4) | 488(18) | 2932(9) | 1073(2) | 4059(1) | 1067(7) | 386(9) | 1599 |
| ICPL 90046 | 1137(15) | 707(12) | 1651(2) | 771(13) | 2546(14) | 756(11) | 3208(8) | 880(14) | 200(16) | 1369 |
| ICPL 90048 | 1228(8) | 788(10) | 1028(14) | 521(17) | 2438(16) | 566(15) | 3210(7) | 1157(3) | 177(17) | 1327 |
| ICPL 90050 | 1514(3) | 171(18) | 1170(8) | 1014(6) | 2901(10) | 795(7) | 2565(15) | 972(10) | 231(15) | 1430 |
| ICPL 90052 | 1279(6) | 1748(1) | 1139(10) | 819(11) | 2469(15) | 787(9) | 2755(14) | 764(17) | 116(18) | 1264 |
| ICPL 90053 | 1147(14) | 971(7) | 1073(12) | 719(15) | 2609(12) | 648(13) | 3163(10) | 1019(9) | 324(12) | 1404 |
| ICPL 90054 | 1184(13) | 901(8) | 905(18) | 1146(4) | 2562(13) | 587(14) | 2392(16) | 972(11) | 525(3.5) | 1338 |
| Control | | | | | | | | | | |
| UPAS 120 | 1002(16) | 1122(5) | 1374(6) | 930(9) | 2392(17) | 867(1) | 3287(5) | 1103(6) | 308(13) | 1411 |
| SE | ±140.0 | ±202.7 | ±245.1 | ±74.0 | ±280.1 | ±33.4 | ±662.2 | ±110.7 | ±34.6 | |
| Mean | 1240.7 | 897.6 | 1225.8 | 914.0 | 2892.6 | 750.2 | 3080.6 | 990.7 | 378.9 | |
| CV (%) | 19.5 | 39.1 | 34.6 | 14.0 | 16.8 | 7.7 | 31.0 | 19.3 | 15.7 | |

1. Figures in parentheses indicate ranks

## Groundnut

### LG-610(90) IC/IC: International cooperation

**Scientist: SNN**

**Seed supply**

**International trials.** We sent the following international trials to our cooperators in different countries:

| Country | Trial |
|---|---|
| Bangladesh | Fifth ICGVT |
| Burkina Faso | Fifth IFDRGVT & Fifth IIPRGVT |
| Ethiopia | Fifth ISGVT & Fifth IMGVT(SB) |
| Sierra Leone | Fifth ISGVT, Fifth IMGVT(SB) & Fifth IFDRGVT |
| South Africa | Fifth ISGVT & Second IDTGVT |
| Sudan | Fifth IIPRGVT & Fifth IFDRGVT |
| Thailand | Fifth IFDRGVT & Fifth ISGVT |
| Venezuela | Fifth IMGVT(VB), Fifth ICGVT & Fifth IFDRGVT |
| Vietnam | Fifth ISGVT |

We also sent one set of an elite drought tolerant trial to a cooperator in India.

**Breeding populations.**One hundred and eighty-eight advanced breeding lines were supplied to our cooperators in Algeria, Barbados, Gambia, India, Indonesia, Sierra Leone, South Africa, Sudan, Thailand, USA, and the People's Republic of China. We supplied nine lines to FAO, Italy for conducting a trial in Oman. We also supplied 39 segregating populations to a cooperator in India.

**Breeder seed.** Breeder seed of ICGS 76 (25 kg) was supplied to the Maharashtra State Cooperative Oilseeds Growers' Federation Limited. We also supplied small quantities of ICGS 44, ICGS 76, ICGS 11, ICGS 37, and ICGV 86590 to private seed producing companies.

**Seed supply to farmers.** In India, 61 farmers received 122 kg pods of ICGS 44, and 11 farmers received 28 kg of ICGS 37.

**Results.** Results received on international trials, collaborative trials, and demonstrations are discussed under the respective breeding projects.

### On-Farm Trials on Integrated Management of Groundnut Diseases

In collaboration with the Andhra Pradesh Agricultural University (APAU) scientists and ICRISAT Center groundnut breeders, pathologists, and entomologists, we conducted on-farm experiments on the integrated management of fungal foliar diseases of groundnut on five farmer's fields in Ganapavaram village and one farmers' field in Karlapalem village, Bapatla, Guntur District, Andhra Pradesh. The objectives of these experiments were:

1. to demonstrate and advise on judicious use of fungicides in groundnut production,
2. to evlauate the economics of the use of fungicides,
3. to evaluate the stability of disease resistance and its response to fungicide spray, and
4. to obtain farmers' views on ICRISAT's disease-resistant groundnut lines.

At Ganapavaram, the late leaf spot and rust resistant cultivar ICGV 86590 was sown in a 400 $m^2$ plot and compared with the farmers' variety TMV 2. Each plot was divided into two halves. One half was sprayed with chlorothalonil, Kavach® (needbased) and another was left to the farmers practice (spray at different timings with different chemicals). In both the villages we have also sown ICGS 44 in large plots of 0.5 h to demonstrate the judicious use of fungicides.

We visited these trials at different intervals throughout the season and collected data on crop growth and disease development and accordingly advised the farmers on fungicide use. Some of the observations recorded at crop maturity were:

1. TMV 2 is the most commonly grown cultivar,
2. Late leaf spot was the predominant foliar fungal disease with damage levels scored at between 4 and 9 on the 1-9 point scale, and
3. Rust attack was negligible in farmers' fields but was moderate to severe at the research station.

Generally the severity of late leaf spot was more (6-8 on a 1-9 rating scale) in the groundnuts sown at high plant population densities (230 kg seeds $ha^{-1}$) than at optimum plant density (135 kg seeds $ha^{-1}$) plots.

There were clear differences in the severity of late leaf spot between plots sprayed two times with Kavach® (4-6 score on a 9-point scale) depending on the need, and plots sprayed more than five times on a time scale (6-8 scores on a 9-point scale).

The severity of rust and late leaf spot on ICGV 86590 was low (2-4 leaf spots and 1-2 rust pustules on lower leaves) in both sprayed and nonsprayed plots. Farmers were generally appreciative of the cultivars ICGV 86590 and ICGS 44.

**On-Farm Trials**

Groundnut on-farm trials organized in coastal Andhra Pradesh to demonstrate correct use of insecticides have given outstanding results. The farmers in Ganapavaram who were using about 14% of their total inputs on the control of insect pests have realized the importance of our technology and achieved excellent yields without any investment on pesticides. This rapid success was mainly due to excellent cooperation and understanding between farmers and researchers who used field visits to collect valuable information on many aspects of crop production (**Fig. 15**).

During this exercise, the farmers realized the importance of encouraging the presence of natural enemies of pests in their fields and have taken steps to take maximize their activities.

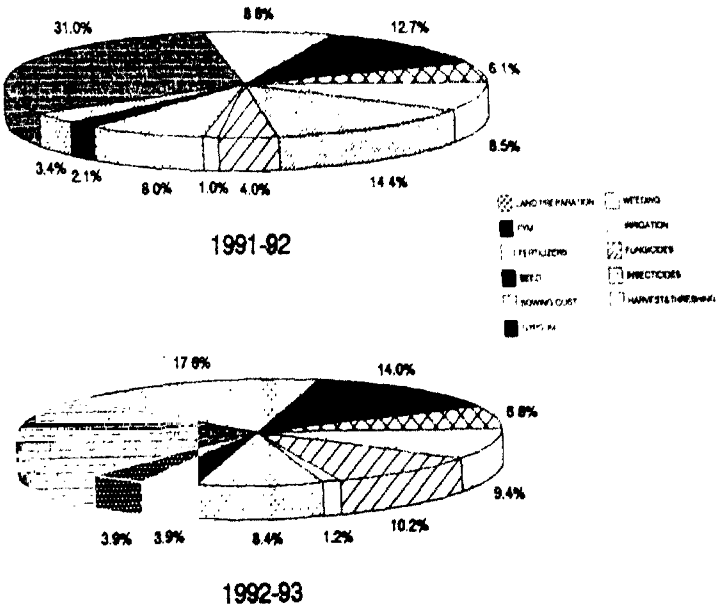


*Figure 15. Results of various inputs into groundnut crop during the 1991/92 and 1992/93 postrainy seasons in Karlapalem and Ganapavaram villages of coastal Andhra Pradesh.*

## Cereals and Legumes Asia Network (CLAN)

### Workshops and Meetings

#### Indonesia-CLAN Review and Work Plan Meeting, 18-19 Jan, Bogor, Indonesia

Thirty scientists and research administrators from the six regional food crops research institutes under the Agency for Agricultural Research and Development (AARD), the Department of Agriculture, Directorate of Food Crops, and the Provincial Agricultural Extension Office, participated in the first Indonesia-CLAN Review and Work Plan Meeting. ICRISAT was represented by D.E. Byth, C.L.L. Gowda, C. Johansen, and S.N. Nigam. Participants reviewed results of past research on groundnut, sorghum, and pigeonpea problems and prepared plans for future collaborative research under CLAN. Long-term strategies needed for strengthening research and development for the current minor crops (sorghum and pigeonpea) were debated, and the national program staff were requested to provide these for incorporation into the work plan. A work plan containing the details of collaborative activities has been prepared.

The results of the Asian Grain Legumes On-farm Research (AGLOR) project (mainly on groundnut, but some on pigeonpea) were reviewed. Plans made for next season include large-scale testing (about 25 ha in each village) of improved groundnut production technologies in Tuban and Subang districts in Java.

#### Thailand-CLAN Review and Work Plan Meeting, 21-22 Jan, Bangkok, Thailand

This was the first CLAN Review and Work Plan Meeting in Thailand. Nine scientists and administrators from the Department of Agriculture, Field Crops Research Institute, Bangkok, and the Field Crop Research Centers at Khon Kaen and Suphanburi participated in the meeting. Thai scientists presented the results of past research on groundnut, sorghum, and pigeonpea and indicated areas for future collaborative research. Groundnut is an important food crop, but sorghum and pigeonpea are still minor crops. A joint work plan indicating agreed areas for collaborative research has been prepared.

#### Study tour of on-farm research trials, Nepal (8-12 Feb) and Vietnam (15-17 Feb)

The Study Tour was co-sponsored by the FAO-RAS/89/040 Project and ICRISAT and hosted by the national programs of Nepal (Nepal Agricultural Research Council) and Vietnam (Ministry of Agriculture and Food Industry). The main objective was to visit the different on-farm adaptive trials conducted under the AGLOR Project. Eighteen participants from 10 member-countries of RAS, FAO, and ICRISAT visited AGLOR trials in Nepal; and 28 participants from 12 countries, FAO, CGPRT Centre, Asian Development Bank, and ICRISAT visited the AGLOR trials in Vietnam. In both countries, the participants gained information on the steps and procedures followed in planning and conduct of on-farm trials. Discussions with farmers and extension staff from the country programs provided participants with an insight into the progress of the AGLOR project. Four study groups (viz., constraint identification, planning of on-farm trials, farmer participation, and dissemination and diffusion of technology) were formed to collect and elicit information that could be used later for the discussion groups at the workshop (see below).

#### Regional Workshop on On-farm Adaptive Research, 18-20 Feb, Ho Chi Minh City, Vietnam

The workshop was co-sponsored by the FAO-RAS/89/040 Project, CGPRT Centre, and ICRISAT in collaboration with the Ministry of Agriculture and Food Industry, Vietnam. Thirty-two scientists from the RAS project countries (Bangladesh, People's Republic of China, Indonesia, South Korea, Laos, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam) and from FAO, CGPRT Centre, ICRISAT, and the Asian Development Bank participated in the workshop The AGLOR Project countries (Indonesia, Nepal, Sri Lanka, and Vietnam) presented the on-farm research case studies, followed by presentation of reports on on-farm research programs and methodologies followed by the different countries, and experiences from other organizations in the Asia region Participants appreciated the progress of the AGLOR project in each of the four project countries, and made several suggestions for improvements in the quality of experiments, conduct of trials, involvement of extension staff in on-farm research, and efforts needed to disseminate technology and assess impact

**Second Botrytis Gray Mold of Chickpea Working Group Meeting, 14-17 Mar, Rampur, Nepal**

The Cereals and Legumes Asia Network in collaboration with the Nepal Agricultural Research Council (NARC) organized the second working group meeting on Botrytis Gray Mold (BGM) of chickpea at Rampur, Nepal, during 14-17 Mar 1993 The working group consists of interested scientists from Bangladesh, India, Nepal, Pakistan, and ICRISAT The first meeting was held in Dhaka, Bangladesh in Mar 1991.

Fifteen participants from Bangladesh (2), India (3), Nepal (5), Pakistan (2), and ICRISAT (3) participated in the meeting. Representatives from the countries and ICRISAT presented results of experiments conducted as per the earlier work plan, and reviewed the research carried out during the last 2 years. The group reiterated that in the absence of high levels of resistance to BGM in chickpea, integrated disease management should be followed. Emphasis in the future research plans will be on cultural and biological control, and on microclimatic studies

**Monitoring Tours**

**Monitoring tour of chickpea and pigeonpea experiments in Myanmar, 24 Jan - 1 Feb**

Three ICRISAT scientists (Onkar Singh, M.P Haware, and N B Singh) participated in the monitoring tour of chickpea and pigeonpea experiments in the central dry zone of Myanmar during 24 Jan - 1 Feb 1993. Areas under pigeonpea and chickpea have increased during the last 3 years, mostly because of higher market prices in the country and for exports. Pigeonpea and sorghum crops showed better drought tolerance than other crops during the July 1992 drought. Five ICRISAT-developed chickpea varieties (ICCV 2, ICCV 5, ICCV 88202, ICCC 42, and ICC 4958) were in large scale multiplication and testing. Pigeonpea lines ICPL 87 and ICPL 151 were also in large multiplication blocks for seed supply for farmers' field tests. Among chickpea diseases, dry root rot and fusarium wilt are important Sterility mosaic of pigeonpea was observed frequently, while fusarium wilt was sporadic in farmers' fields.

**Monitoring tour of groundnut and pigeonpea experiments in Sri Lanka**

The area under pigeonpea in 1993 is around 300 ha against a target of 400 ha. Seed supply to farmers has been a problem in some areas, while in others there was insufficient follow-up activity. Overall, the crop was good, although pest management was still a problem in some districts. A few more dehulling machines will be distributed to ease the dhal milling problem and farmers will be provided with training in dhal making.

The groundnut AGLOR on-farm research trials were visited Trials were good in Hambantota and Monaragala. The high-input package trials for Mahaweli irrigated areas were not conducted with all the recommended package of practices. Bud necrosis disease was a problem in the late sown crop. Suggestions were made to improve the conduct of trials.

**Human Resource Development**

Dr. Nguyen Kim Vu, Microbiologist, INSA, Hanoi, Vietnam has joined on 11 Mar 1993 as Research Fellow to get training in *Rhyzobium* inoculum production.

Five technicians from China, Myanmar, Nepal, Thailand, and Vietnam have joined the 6-week Intensive English course, prior to undergoing the 6-month in-service training course starting in May 1993.

# General Program Matters

## Staff Postings, Duties, etc.

N.P. Saxena visited ICRISAT from 29 Dec 1992 to 3 Feb During his stay he worked on the proceedings of the WANA Chickpea Adaptation Workshop and News and Views of the Global Grain Legumes Drought Research Network (GGLDRN).

Ravi Chandekar, Field Attendant, was transferred from Legumes Physiology to the Information Management and Exchange Program effective 5 Feb.

D.V.R. Reddy returned to IC on 7 Mar on completion of his study leave in the USA.

T.P. Rao, Research Associate, GOJ Project was sent to the National Agriculture Research Center, Tsukuba, Japan for 5 months from 13 Mar to carry out $^{15}N$ natural abundance analyses for both the GOJ Project and the Unit's $N_2$-fixation project

Jagdish Kumar, completed his work with the Crop Diversification Program of CIDA in Bangladesh and returned to IC on 31 Mar.

### Postdoctoral Fellows

R.V. Satyanarayana Rao, returned to the Indian Agricultural Research Institute, New Delhi on 15 Jan after completing his final project report on "Screening for resistance to groundnut leaf miner *Aproaerema modicella* (Deventer) in *Arachis hypogaea* and wild *Arachis* species".

M.K. Naik left ICRISAT on 22 Jan to join the Indian Institute of Horticultural Research, ICAR, Hassarighatta, Bangalore after completion of his assignment with the Pathology Unit.

Maria Luz J. Sison completed her research on the topic "Groundnut leaf miner, *Aproaerema modicella* (Dev) and its natural enemies on eight groundnut genotypes" and left on 14 Mar.

Prasun Kumar Mukherjee left ICRISAT on 22 Mar to join the Bhabha Atomic Research Center (BARC), Bombay after partial completion of his assignment with the Cell Biology Unit.

Shiv Kumar Agrawal completed his term in the Chickpea Breeding Unit.

M. Satya Prasad completed his assignment in the Cell Biology Unit on 28 Mar.

S.D. Golombek joined the Crop Physiology Unit as Post Doctoral Fellow on 10 March.

### CLAN

C.L.L. Gowda was appointed Coordinator, Cereals and Legumes Asia Network (CLAN) effective 1 Jan 1993.

T.P. Ravindran joined CLAN as Asst. Administrative Officer effective 1 Mar 1993, and G. Shinde was transferred to the Personnel Division from 22 Mar 1993.

## Staff Travel

Details of staff travel to various places within and outside India are furnished in Appendices I and II.

## Workshops/Meetings/Conferences

Details of participation in different workshops, meetings, conferences, etc. from ICRISAT Center, ICARDA (ICRISAT/ICARDA Chickpea Project), and EARCAL are furnished in Appendix III.

## Research Coordination

Chickpea scientists met on 5 Jan to discuss on-going research in chickpea. They also discussed research planning for 1993 and for the 1994-98 Medium Term Planning (MTP) period.

## Training Activities, Seminars, Group Meetings, etc.

### Training Activities

D.R. Saxena, Junior Scientist in Plant Pathology, Jawaharlal Nehru Krishi Vishwavidyalaya, Zonal Agricultural Research Station, Khargone, Madhya Pradesh spent three weeks (8-26 Feb) as a Research Fellow at IC and received training in identification and detection of chickpea viruses.

Guo, Gaoqiu, Director of Legumes Office, Crops Research Institute of the Qinghai Academy of Agriculture and Forestry, Xining, Qinghai Province, People's Republic of China was a Research Fellow in the Crop Physiology Unit. He also spent 2 weeks with the Chickpea Breeding Unit to become acquainted with chickpea breeding activities.

Nguyen Kum Vu, Research Fellow from Vietnam visited the Crop Physiology Unit for 1 month to work on $N_2$-fixation.

### Seminars

M.K. Naik presented a seminar on "Ecology of fusarium wilt of pigeonpea" on 15 Jan.

M.P. Haware delivered his award lecture at the 45th Indian Phytopathological Society Annual Meeting on 20 Jan at the Punjabrao Krishi Vidyapeet, Akola, Maharashtra.

G.V. Ranga Rao gave a talk on insect pest management to 15 M.Sc. students from the University of Hyderabad on 10 Feb.

N.J. Armes presented a seminar on "Resistance to insecticides in *H. armigera* in India" at the Central Institute for Cotton Research on 11 Mar.

Prasun Kumar Mukherjee presented a seminar on "Biological control of plant pathogens" on 22 Mar.

T.G. Shanower presented a lecture "Biology, ecology and control of the groundnut leaf miner" at the Indian Institute of Horticultural Research, Bangalore.

D.V.R. Reddy gave two invited lectures on "Virus Research at ICRISAT Center" at the Plant Pathology Department in the University of Florida, Gainsville and at the Samuel Roberts Noble Foundation in Ardmore, OK, USA.

### Doordarshan (Television)

G.V. Ranga Rao gave a talk to Andhra Pradesh farmers on Doordarshan covering insect pest management in groundnut on 18 Jan.

Doordarshan organized filming of on-farm activities at Karlapalem and Ganapavaram, 9-10 Mar and interviewed Drs. D. McDonald and J.A. Wightman on 19 Mar

## Publications

### Newsletter

International Chickpea Newsletter no. 27 was released in March.

The first issue of the Joint ICRISAT/ICARDA News and Views of the Global Grain Legume Drought Research Network (GGLDRN) edited by N P. Saxena, C Johansen, and M.C. Saxena was released in Jan.

### Information Bulletins

Pigeonpea and Chickpea Insect Identification Handbook (Chinese version, IBC 026).

Field Diagnosis of Chickpea Diseases and their control (Arabic version IBA 028).

### Plant Material Descriptions

A proposal was submitted to the Plant Materials Identification Committee (PMIC) for identification and release of four improved jassid-resistant groundnut germplasm lines.

### Conference Proceedings

**Nigam, S.N.** (ed.) 1992. Groundnut — a global perspective: proceedings of an international workshop, 25-29 Nov 1991. ICRISAT Center, India. (In En. Abstracts in Eng, Fr, Es.) Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 548 pp. ISBN 92-9066-239-5. Order Code: CPE 081.

### Journal Articles

**Haq, M.A., Singh, K.B., Abidin, Z.,** and **Ahmed, M.S.** 1992. Mutation studies in chickpea (*Cicer arietinum*); 1. Mutagen sensitivity. Pakistan Journal of Agricultural Sciences 29: 429-439.

**Ocampo, B., Venora, G., Errico, A., Singh, K.B., and Saccardo, F.** 1992. Karyotype analysis in genus *Cicer.* Journal of Genetics and Breeding 46: 229-240. (JA 1325)

**Patrick, G. Lanham, Sarah Fennell, J.P. Moss,** and **W. Powell.** 1992. Detection of polymorphic loci in *Arachis* germplasm using random amolified polymorphic DNAs. Genome 35:885-889. (JA 1322)

**Ramakrishna, A., Rupela, O.P., Reddy, S.L.N.,** and **Sivaramakrishna, C.** 1992. Promising herbicides for weed control in chickpea. Tropical Pest Management 38: 398-399. (JA 1197)

**Reddy, D.V.R., Richins, R.D., Rajeshwari, R., Iizuka, N., Manohar, S.K.** and **Shepherd, R.J.** 1993. Peanut chlorotic streak virus, a new caulimovirus infecting peanuts (*Arachis hypogaea*) in India. Phytopathology 83(2):129-133.

**Shanower, T.G., Wightman, J.A.** and **Gutierrez, A.P.** 1993. Biology and control of the groundnut leaf miner, *Aproaerema modicella* (Deventer) (Lepidoptera: Gelechiidae). Crop Protection 12(1): 3-10.

**Singh, K.B. and Reddy, M.V.** 1993. Resistance to six races of *Ascochyta rabie* in the world collection of germplasm of chickpea. Crop Science 33: 186-189 (JA 1290).

**Conference Papers**

**Reddy, M.V.,** and **Jain, K.C.** 1992. Recent advances in breeding for disease resistance in pigeonpea. Pages 77-83 *in* New frontiers in pulses research and development: proceedings of National Symposium, 10-12 Nov 1989, Kanpur, India (Sachan, J.N., ed.). Kanpur, India: Directorate of Pulses Research. (CP 579)

**Saxena, K.B., Ariyanayagam, R.P.** and **Chithrai, G.M.W.** 1992. Problems of transferring milling technology to new potential areas - an experience with red gram milling in Sri Lanka. Pages 57-72. *In* Proceedings of a National Seminar on "dhal milling industry in India - its future needs", 10-11 Feb 1993, New Delhi, India: Centre for Agricultural Productivity, National Productivity Council.

**Progress Reports**

**Dwivedi, S.L., G.V.S. Nagabhushanam, and S.N. Nigam. 1993.** Progress Report: LG-609(90)IC/IC. Breeding groundnut for confectionery traits — yield trials. Progress Report no. 2/93, Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics (Limited distribution.)

**Dwivedi, S.L., G.V.S. Nagabhushanam,** and **S.N. Nigam.** 1993. Project Progress Report: LG-604(90)IC/IC. Breeding for resistance to insect pests — yield trials. Progress Report no. 3/93. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics (Limited distribution.)

**Nigam, S.N.,** and **Y.L.C. Rao.** 1993. Project Progress Report: LG-607(90)IC/IC. Breeding medium-duration groundnut varieties with resistance to multiple stress factors — yield trials. Progress Report no. 4/93. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics (Limited distribution.)

**Accepted for Publication**

**Ranga Rao, G.V.** and **Anitha, V.** 1993. Survey report of the occurrence of groundnut pod borers in southern India. 'Indian Journal of Plant Protection. (JA 1471).

**Saxena, K.B., Singh, L.,** and **Ariyanayagam,R.P.** (in press). Role of partial cleistogamy in maintaining genetic purity of pigeonpea. Euphytica (JA 1418).

# Visitors

Details of various cooperators, administrators, and NARS scientists visited ICRISAT Center, ICARDA (ICRISAT/ICARDA Chickpea Project) in Syria, and EARCAL in Kenya are given in Appendix IV.

# Project Scientists

### Chickpea Breeding

| | | |
|---|---|---|
| HAvR | H.A. van Rheenen | Principal Scientist (Breeding) |
| JK | Jagdish Kumar | Senior Scientist (Breeding) |
| OS | Onkar Singh | Senior Scientist (Breeding) |
| SCS | S.C. Sethi | Senior Scientist (Breeding) |

### Pigeonpea Breeding

| | | |
|---|---|---|
| RPA | R.P. Ariyanayagam | Principal Scientist (Breeding) |
| KBS | K.B. Saxena | Senior Scientist (Breeding) |
| KCJ | K.C. Jain | Scientist (Breeding) |
| NBS | N.B. Singh | Visiting Scientist (Breeding) |

### Groundnut Breeding

| | | |
|---|---|---|
| SNN | S.N. Nigam | Principal Scientist (Breeding) |
| LJR | L.J. Reddy | Senior Scientist (Breeding) |
| SLD | S.L. Dwivedi | Scientist (Breeding) |
| HDU | H.D. Upadhyaya | Scientist (Breeding) |

### Cell Biology

| | | |
|---|---|---|
| JPM | J.P. Moss | Principal Scientist (Cell Biology |
| KKS | K.K. Sharma | Scientist (Cell Biology) |
| NM | Nalini Mallikarjuna | Scientist (Cell Biology) |
| MSP | M. Satya Prasad | Postdoctoral Fellow |
| PSB | P.S. Badami | Postdoctoral Fellow |
| PL | Prasanna Lata | Research Scholar |
| SVN | S.V. Naik | Research Scholar |

### Crop Physiology

| | | |
|---|---|---|
| CJ | C. Johansen | Principal Scientist(Physiology) |
| NPS | N.P. Saxena | Senior Scientist (Physiology) |
| JVDKKR | J.V.D.K. Kumar Rao | Senior Scientist (Physiology) |
| OPR | O.P. Rupela | Senior Scientist (Physiology) |
| YSC | Y.S. Chauhan | Scientist (Physiology) |
| RCNR | R.C. Nageswara Rao | Scientist (Physiology) |
| LKM | L. Krishna Murthy | Senior Research Associate |
| NHN | N.H. Nam | Research Scholar |

## Government of Japan Project

| | | |
|---|---|---|
| OI | O. Ito | Principal Scientist (Physiology) |
| KK | K. Katayama | Senior Scientist (Physiology) |
| JJAG | J.J. Adu-Gyamfi | Postdoctoral Fellow |

## Entomology

| | | |
|---|---|---|
| JAW | J.A. Wightman | Principal Scientist(Entomology) |
| NJA | N.J. Armes | Principal Scientist(Entomology) |
| TGS | T.G Shanower | Scientist (Entomology) |
| CSP | C.S. Pawar | Scientist (Entomology) |
| GVRR | G.V. Ranga Rao | Scientist (Entomology) |
| KVL | K. Vijaya Lakshmi | Research Scholar |

## Pathology

| | | |
|---|---|---|
| MVR | M.V. Reddy | Senior Scientist (Pathology) |
| MPH | M.P. Haware | Senior Scientist (Pathology) |
| VKM | V.K. Mehan | Scientist (Pathology) |
| SP | Suresh Pande | Scientist (Pathology) |
| SBS | S.B. Sharma | Scientist (Nematology) |
| DRB | D.R. Butler | Principal Scientist (Microclimatology) |

## Virology

| | | |
|---|---|---|
| DVRR | D.V.R. Reddy | Principal Scientist (Virology) |
| RAN | R.A. Naidu | Scientist (Virology) |
| PB | E.P. Broglio | Postdoctoral Fellow |
| AAMB | A.A.M. Buiel | Research Scholar |
| VW | Varsha Wesley | Research Scholar |

## ICRISAT/ICARDA Chickpea Project

| | | |
|---|---|---|
| KBS | K.B. Singh | Principal Scientist(Breeding) |

## EARCAL

| | | |
|---|---|---|
| LS | Laxman Singh | Principal Scientist(Agronomy) |
| SNS | S.N. Silim | Senior Scientist(Agronomy) |

# Appendices

**Appendix I**

**Visits by Legumes Program Staff to different places within India during Jan-Mar 1993.**

| Period | Staff name(s) | Organization/ Location | State(s)/ Region | Purpose |
|---|---|---|---|---|
| 06-12 Jan | M V. Reddy | Different | S. India | To monitor joint ICRISAT-ICAR pigeonpea trials |
| 08-10 Jan | J A Wightman<br>G.V. Ranga Rao<br>V.R. Bhagwat | Bapatla | Andhra Pradesh | To visit on-farm trials |
| 10-12 Jan | Suresh Pande | Bapatla<br>Karlapalem<br>Ganapavaram | Andhra Pradesh | To monitor and collect data on on-farm trials on integrated management of fungal foliar diseases of groundnut |
| 11-23 Jan | Henk A.van Rheenen | Coimbatore<br>Aruppukottai<br>Kovilpatti<br>Badnapur<br>Parbhani | Tamil Nadu<br><br><br>Maharashtra | To visit and discuss joint breeding experiments |
| 17-24 Jan | R.C. Nageswara Rao (with M.S. Basu, ICAR) | UAS, Bangalore<br>ARS, Vridha-chalam<br>RRS, Tirupati<br>ARS, Anantapur | Karnataka<br>Tamil Nadu<br><br>Andhra Pradesh | To confer with scientists involved in water use efficiency (WUE) project |
| 18-21 Jan | T.N. Raju | Akola | Maharashtra | To present posters in the 45th Annual Meeting of the IPS |
| 18-23 Jan | S.C. Sethi<br>Abu Musa | Lam, Guntur<br>Gulbarga | Andhra Pradesh<br>Karnataka | To see chickpea experiments and visit farmers' fields |
| 27 Jan-02 Feb | R.C. Nageswara Rao (with M.S. Basu, ICAR) | New Delhi<br>Durgapura<br>Ahmedabad | New Delhi<br>Rajasthan<br>Gujarat | To confer with scientists involved in WUE project |
| 28-30 Jan | Suresh Pande | Bapatla | A.P. | To monitor diseases in groundnut |
| 29 Jan-07 Feb | D.R. Jadhav<br>K.V.S. Satya-narayana<br>M. Satyanarayana | Different | Orissa<br>Madhya Pradesh | To survey and collect *H. armigera* for insecticide resistance |
| 30 Jan-02 Feb | M.V. Reddy | Lam<br>Darsi<br>Madhira | Andhra Pradesh | To evaluate pigeonpea lines for resistance to Macrophomina root rot in ICRISAT-APAU cooperative trial at Madhira and assess the disease situation in farmers fields |

*Continued*

**Appendix I. *Continued.***

| Period | Staff name(s) | Organization/ Location | State(s)/ Region | Purpose |
|---|---|---|---|---|
| 08-17 Feb | O.P. Rupela | Gwalior<br>HAU, Hisar | Madhya Pradesh<br>Haryana | To observe field trials and explore research collaboration with HAU, and PAU, Ludhiana |
| 10-13 Feb | T.G. Shanower | Nanded<br>Parbhani | Maharashtra | To collect samples of ICRISAT pigeonpea genotypes grown by farmers and to evaluate farmer preferences for improved and local genotypes |
| 11-15 Feb | O.S. Tomar | Akola | Maharashtra | To visit chickpea growing areas and monitor performance and adoption of varieties |
| 13-16 Feb | S.C. Sethi | Hisar | Haryana | To monitor and take observations in chickpea collaborative trials |
| 15-18 Feb | R.C. Nageswara Rao (and M.S. Basu, ICAR) | Jalgaon<br>Ahmednagar<br>Aurangabad | Maharashtra | To discuss the WUE project with cooperating scientists |
| 17-19 Feb | Onkar Singh | Akola | Maharashtra | To monitor collaborative chickpea breeding trials |
| 17-26 Feb | S. Jayanthi | Hisar<br>Pantnagar | Haryana<br>Uttar Pradesh | To survey and take initial observations on chickpea pathology trials |
| 23-26 Feb | N.J. Armes | TNAU, and CICR, Coimbatore | Tamil Nadu | For final planning on implementation of collaborative projects on *H. armigera* insecticide resistance monitoring and management |
| 01-02 Mar | R.A. Naidu | Guntur<br>Bapatla | Andhra Pradesh | To collect peanut clump infested soils |
| 01-06 Mar | S.C. Sethi | Baroda | Gujarat | To monitor the adoption of ICCV 1 and other chickpea varieties and to see front line demonstra-tions of ICCV 10 in Gujarat State |
| 01-08 Mar | C.S. Pawar | CIAE, Bhopal<br>ASPEE, Bombay | Madhya Pradesh<br>Maharashtra | To discuss pesticide application techniques |
| 03-04 Mar | S.N. Nigam<br>Suresh Pande<br>RMP scientists | Banagana-palli | Andhra Pradesh | To monitor the 1992/93 postrainy season groundnut on-farm trials conducted by RMP and the Krishi Vigyan Kendra on the development of iron chlorosis |
| 09 Mar | S.C. Sethi | Hisar | Haryana | To monitor experiments and to inspect a large scale multipli-cation area of ICCV 10. |
| 09-10 Mar | Suresh Pande | Bapatla | Andhra Pradesh | To monitor groundnut trials |

*Continued*

**Appendix I. *Continued.***

| Period | Staff name(s) | Organization/ Location | State(s)/ Region | Purpose |
|---|---|---|---|---|
| 10-11 Mar | S.C. Sethi | Gwalior | Madhya Pradesh | To monitor breeding trials |
| 10-12 Mar | M.V. Reddy | Raichur | Karnataka | To visit the on-going perennial pigeonpea trial and to advise on future course of action |
| 10-12 Mar | N.J. Armes | CICR, Nagpur | Maharashtra | To discuss implementation of a collaborative project on *H. armigera*, insecticide resistance monitoring and management |
| 13 Mar-<br>12 Apr | Suresh V. Naik | IARI | New Delhi | To learn molecular biology techniques of RFLPs and mapping |
| 16-19 Mar | P.M. Reddy | Bapatla | Andhra Pradesh | To evaluate IGLDN/IGRDN trials and to rougue out off-types in ICG(FDRS) 10 and ICGS 86590 |
| 17-29 Mar | Onkar Singh | Gwalior<br>Sehore | Madhya Pradesh | To evaluate chickpea breeding materials grown under the collaborative projects |
| 19 Mar | L.J. Reddy | Rajendra-<br>nagar<br>Narkoda | Andhra Pradesh | Monitoring tour organized by DOR to the breeders' seed production plots of ICRISAT groundnut varieties ICGs 11 and ICG(FDRS) 10 |
| 23-28 Mar | A.S. Reddy | Different | West Bengal<br>and Assam | To participate in joint surveys for peanut stripe virus with ICAR scientists |
| 27 Mar -<br>11 Apr | Mohd. Aziz | Gwalior | Madhya Pradesh | For harvesting chickpea collaborative trials |
| 28 Mar-<br>06 Apr | S. Jayanthi | Hisar<br>Pantnagar | Haryana<br>Uttar Pradesh | To record final observations in chickpea pathology trials |
| 29-31 Mar | S.C. Sethi | Pantnagar | Uttar Pradesh | To score for BGM symptoms and make and make selections in chickpea trials |
| 30-31 Mar | O. Ito<br>K. Katayama<br>and 2 officials | Zaheerabad<br>Vikarabad<br>Chevella<br>Bidar | Andhra Pradesh<br><br><br>Karnataka | To show visiting delegates of Government of Japan the farming systems practised in the two States |

**Visits by Legumes Program Staff to countries other than India during Jan-Mar 1993.**

| Period | Staff name(s) | Country(s)/ Region | Purpose |
|---|---|---|---|
| 19 Dec 92 11 Mar 93 | N.H. Nam | Vietnam | To discuss with his adviser regarding format and contents of his thesis and to attend to official work of Crop Physiology Unit and AGLOR Project |
| 17-29 Jan | R.P.Anyanayagam | Venezuela Ecuador | To monitor trials, discuss pigeonpea research and conduct a conduct a training course on pigeonpea improvement |
| 23 Jan-02 Feb | O. Ito | Japan | To take home leave and to visit TARC to appraise officials on progress of work in GOJ special project |
| **EARCAL** | | | |
| 06-18 Mar | S.N Silim | Malawi Mozambique and Swaziland | To develop collaborative work, and to visit SADC/ICRISAT Zimbabwe to discuss coordination of AfDB |
| **CLAN (ICRISAT Staff travel to CLAN member countries)** | | | |
| 17-19 Jan | D.E Byth<br>C.L.L. Gowda<br>C Johansen<br>S.N. Nigam | Indonesia | To attend Indonesian CLAN Review and Work Plan meeting at CRIFC, Bogor |
| 21-22 Jan | D.E. Byth<br>C.L.L. Gowda<br>S.N. Nigam | Thailand | To attend Thailand-CLAN Review and Work Plan meeting at FCRI, Bangkok |
| 21-23 Jan | C. Johansen | Thailand | To discuss proposed acid soils network at IBSRAM, Bangkok |
| 24 Jan-1 Feb | Onkar Singh<br>M.P. Haware<br>N.B. Singh | Myanmar | To monitor collaborative chickpea and pigeonpea experiments, and carry out disease survey of chickpea |
| 3-13 Feb | Onkar Singh<br>K.C. Jain | Nepal | To visit on-farm trials, and participate in the FAO/ICRISAT study tour of on-farm trials |
| 6-13 Feb | C.L.L. Gowda<br>S.C. Sethi | Nepal | To participate in the FAO/ICRISAT Study Tour of on-farm trials |
| 7-13 Feb | S.N. Nigam | Philippines | To visit PCARD amd groundnut research program in IPB, and and Cagayan valley |
| 14-21 Feb | M.C.S. Bantilan<br>C.L.L. Gowda<br>C. Johansen<br>S.N. Nigam | Vietnam | To participate in the FAO/ICRISAT Study Tour of on-farm trials, 15-17 Feb; and Workshop on On-farm Adaptive Research, 18-20 Feb, Ho Chi Minh City, Vietnam |

*Continued*

***Appendix II. Continued.***

| Period | Staff name(s) | Country(s)/ Region | Purpose |
|---|---|---|---|
| 17-21 Feb | Y.L. Nene | Vietnam | To attend Workshop on On-farm Adaptive Research, 18-20 Feb, Ho Chi Minh City, Vietnam |
| 14-21 Feb | S.L. Dwivedi<br>K.B. Saxena | Sri Lanka | To monitor on-farm and on-station trials in groundnut and pigeonpea in Sri Lanka |
| 23 Feb-<br>1 Mar | C. Johansen | Bangladesh | To monitor chickpea experiments in the Barind area, and for discussions with BARI and CDP scientists |
| 12-19 Mar | D.R. Butler<br>M P. Haware<br>S.C. Sethi | Nepal | To participate in the Working Group Meeting on Botrytis Gray Mold of Chickpea, Rampur, 14-17 Mar |
| 19-28 Mar | S.C. Sethi | Nepal | To assist in selection and evaluation of breeding material, and harvest of on-farm research trials |

**Workshops, meetings, and conferences attended by legumes staff during Jan-Mar 1993.**

| Period | Meeting | Location/ Organizer(s) | Country | Staff member(s) |
|---|---|---|---|---|
| 9-12 Feb | Dhal milling industries in India - its future needs | New Delhi | India | A. Nageswara Rao |
| 15 Feb | ASW/CRIDA red hairy caterpillar | Hyderabad | India | G.V. Ranga Rao |
| 16-18 Feb | Biotechnology in Diagnosis and control of viral diseases | Osmania Univ Hyderabad | India | R.A. Naidu<br>A.S. Ratna<br>A.S. Reddy<br>S.V. Reddy |
| 16-19 Feb | 4th National Symposium on Soil Biology and Ecology and present a paper on thresholds of pigeonpea wilt | Bangalore | India | M.V. Reddy |
| 21-27 Feb | International Neem Conference | Bangalore | India | T.G. Shanower<br>M.A. Ghaffar |

**CLAN (Participation of ICRISAT staff in workshops and meetings in Asia, Jan-Mar 1993)**

| | | | | |
|---|---|---|---|---|
| 18-19 Jan | Indonesian-CLAN Review and Work Plan meeting | CRIFC/AARD and CLAN/ICRISAT | Bogor, Indonesia | D.E. Byth<br>C.L.L. Gowda<br>C. Johansen<br>S.N. Nigam |
| 21-22 Jan | Thailand-CLAN Review and Work Plan meeting | FCRI/DOA and CLAN/ICRISAT | Bangkok, Thailand | D.E. Byth<br>C.L.L. Gowda<br>S.N. Nigam |
| 18-20 Feb | Workshop on on-farm adaptive research | FAO-RAS, CGPRT Centre, and ICRISAT | Ho Chi Minh City, Vietnam | M.C.S. Bantilan<br>C.L.L. Gowda<br>C. Johansen<br>Y.L. Nene<br>S.N. Nigam |
| 14-17 Mar | Working Group meeting on Botrytis Gray Mold of Chickpea | NARC and CLAN/ ICRISAT | Rampur, Nepal | D.R. Butler<br>M.P. Haware<br>S.C. Sethi |

**Visitors to Legumes Program from various agricultural research systems and organizations throughout the world during Jan-Mar 1993.**

| Period | Visitors name(s) | Organization/ Location | Country | Purpose |
|---|---|---|---|---|
| 3 Nov 92-<br>9 Feb 93 | Andrew West | University of Reading | UK | To study insecticide resistance mechanisms in *H. armigera* |
| 06 Jan | N.K Sanghi | CRIDA, Hyderabad | India | Visited the Entomology Unit |
| 07 Jan | A K Srivastava | Rajendra Agr. Univ., Bihar | India<br>India | Visited the Pigeonpea Breeding Unit to learn about pigeonpea research, particularly on salt and drought tolerance |
| 09 Jan | R. Paarlberg | NRI | UK | Visited the Entomology Unit |
| 11-13 Jan | M.A. Musa | OFRD/BARI | Bangladesh | Visited the Chickpea and Groundnut Breeding Units, and the Pathology Unit to discuss Barid Research and Development work plan |
| 18 Jan | Pawan Aalok | PAKHRIBAS | Nepal | To discuss the on-going collaborative research activities between ICRISAT and NARC Nepal and possible collaboration with PARC |
| 22 Jan | D.S. Anant<br>G Hunsigi | UAS, Bangalore | India | Governing Board Members of UAS visited Groundnut and Pigeonpea Breeding Units |
| 22 Jan | Sujata Bhargava | Univ. of Poona | India | Overview of crop physiology research |
| 25-29 Jan | C.R. Yadav | NGLRP, Rampur | Nepal | To visit collaborative trials in the Chickpea, Pigeonpea, and Groundnut Breeding Units and to discuss research activities in Crop Physiology and Pathology |
| 27-28 Jan | R.A. Patil<br>R. Rathnaswamy<br>A. Satyanarayana | ARS, Badnapur<br>Coimbatore<br>ARS, Lam | India | To visit collaborative trials |
| 27-29 Jan | 1500 Farmers | Andhra Pradesh | India | Visited Groundnut breeding fields |
| 01-10 Feb | S. Alam Bhuyiyan | BARI | Bangladesh | Presented a seminar on "Tissue culture of groundnut" |
| 02 Feb | 20 Participants | ASCI, Hyderabad | India | To learn about CLAN activities |
| 03 Feb-<br>18 Mar | F.B. Lopez | | | To complete writing up of journal articles derived from his research at ICRISAT |

*Continued*

**Appendix IV. *Continued.***

| Period | Visitors name(s) | Organization/ Location | Country | Purpose |
|---|---|---|---|---|
| 04 Feb | B.S. Thind | PAU, Ludhiana | India | Visited for discussion on groundnut bacterial disease problems |
| 15-19 Feb | K.K. Paliwal | Sehore, M.P | India | To visit Collaborative Trials |
| 19 Feb | Vinod Kumar | Proagro Seeds | India | Visited the Cell Biology Laboratory |
| 22 Feb | Keith Jones | NRI | UK | Visited the Entomology Unit |
| 22-23 Feb | Extension Officers | Bangladesh-Canada Crop Diversification Program | Bangladesh | Visited different Units to acquaint with on-going research activities |
| 24 Feb | G. Appaji | A farmer from Ganapavaram | India | To narrate his success story of pest management to ICRISAT members |
| 25 Feb and 16 Mar | Allan Cork | NRI | UK | Visited the Entomology Unit |
| 01-02 Mar | A.S. Islam | BARI | Bangladesh | Visited the Cell Biology and Breeding Units to discuss techniques of crossing and isozyme analyses |
| 04 Mar | Sue Cowgill | Southampton University | UK | Visited the Entomology Unit |
| 05 Mar | M.E. Roothaan | Royal Vander Have | The Netherlands | Visited the Breeding Units and Cell Biology Laboratory |
| 06-18 Mar | L. Torrance | SCRI | UK | Visited the Virology Unit as Consultant to work on monoclonal antibody production |
| 10 Mar | H.M. Tadria<br>A.A. Guitard | Governing Board Members of ICRISAT | | Visited the Groundnut Breeding Unit |
| 11 Mar | K.J. Brown | CIP | | Visited the Entomology Unit |
| 11-12 Mar | Anurag Goel | ICGEB New Delhi | India | Met with K.K. Sharma and J.P. Moss |
| 12 Mar | P. Balakrishna<br>T. Ravi Shankar | M.S. Swaminathan Research Foundation Madras | India | Visited the Cell Biology Unit |
| 16 Mar | S.K. Gupta<br>Channabavasanna | AICRP UAS, Bangalore | India | To discuss the present status of sterility mosaic disease of pigeonpea |
| 26 Mar | C.G. Campbell | Hill Crops Development Project and Grain Legumes Project | Nepal | Visited Groundnut and pigeonpea Breeding Units and also discussed crop physiology research |

*Continued*

**Appendix IV. *Continued.***

| Period | Visitors name(s) | Organization/ Location | Country | Purpose |
|---|---|---|---|---|
| 29-31 Mar | K. Sakata<br>M. Izumi | Govt. of Japan Officials | Japan | To discuss previous, present, and possible future GOJ support of projects in the Crop Physiology Unit. Also discussed upgrading of the Institute's CCE facilities |
| 31 Mar | G. Rothschild | ACIAR | Australia | Visited the Entomology Unit |
| **CLAN** | | | | |
| 25-31 Jan | C.R. Yadav | NGLRP, Rampur | Nepal | To visit chickpea and pigeonpea research units at ICRISAT and for discussions with CLAN-CU |
| 12-25 Jan | Abu Musa | BARI, Rajshahi | Bangladesh | To visit chickpea research unit at ICRISAT, and visit research stations in A.P. and Karnataka |
| 2 Feb | 20 participants | ASCI, Hyderabad | India | To learn about CLAN activities |
| 2 Mar | M. Hossain<br>A.K.M. Jahangir<br>M. Amanullah<br>M. Mozaffar | DAE, Dhaka | Bangladesh | To learn about CLAN activities |
| 2 Mar | A.S. Islam | Grameena Bank, Dhaka | Bangladesh | To learn about CLAN activities |
| 3 Mar | R.S. Paroda | FAO/RAPA, Bangkok | Thailand | To discuss AGLOR Project activities |
| 26 Mar | C.G. Campbell | IDRC, Kathmandu | Nepal | To learn about CLAN activities |
| 29 Mar | K. Sakata<br>M. Izumi | MAFF, Tokyo | Japan | To learn about CLAN activities |
| 31 Mar | A.K. Kaul<br>P.S. Srinivasan | Winrock, Arkansas<br>Winrock, New Delhi | USA<br>India | To discuss collaborative research areas between Winrock and ICRISAT |